

VIII. CONCLUSIONS AND FUTURE DIRECTIONS OF THE RESEARCH ON PHYSICAL ACTIVITY AND CHILDHOOD COGNITIVE AND BRAIN HEALTH

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ABSTRACT This chapter serves as a summary to the monograph. The main purpose is to concisely merge the individual chapters into a cohesive summary around markers of health behaviors and their relation to childhood cognition and brain health. In addition, future directions for research in this area are briefly discussed with the goal of shaping future research in several directions. Issues surrounding the need for causality and ethical considerations are also described. Finally, this chapter places the link between health behaviors and cognition within the greater context of the educational environment, lifelong health, and effective function.

Over the past few decades, reports have clearly described the declining health of children in industrialized society (Salmon & Timperio, 2007). More recently, evidence has emerged to suggest that the declining health of children extends beyond the physical domain to that of the cognitive domain as well. As such, a body of evidence has materialized that details the relation of physical inactivity, poor physical fitness, and excess adiposity to cognitive and brain health. Such evidence was the foundation of this monograph. Across all chapters, which described different aspects of the physical health to brain and cognition relationship, it is evident that children who maintain higher physical activity behaviors, have greater cardiorespiratory sufficiency, and normal, healthy body mass exhibit better performance across a host of cognitive control and memory tasks that are mediated by specific brain structures and circuits. It is our hope that such evidence fuels the ongoing fight against childhood obesity and related diseases that are prevalent among our youth, and contribute to a scholastic climate that supports and perpetuates physical inactivity.

Accordingly, the purpose of this monograph was to first provide the necessary background delineating that childhood health and fitness are

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declining in industrialized society. Such a rationale was provided in chapters 1 and 2, which offered an overview of the contemporary trends among physical inactivity, fitness, and adiposity. In addition, the science of physical activity and fitness measurement among children was described. Chapters 3 and 4 provided a detailed description of the relation of health markers (i.e., physical activity, aerobic fitness, adiposity, nutrition) on brain structure and function and cognition. Such chapters served to provide a detailed rationale for the relationship of markers of health behavior to cognitive and brain health. Both correlational and intervention studies were described, and the evidence for the relationship between physical health and cognitive and brain health was provided. From these chapters, it is clear that general and selective relationships exist between the various markers of health behaviors and cognition. Chapter 5 provided novel, empirical evidence supporting the positive relation of aerobic fitness, and the negative relation of excess adiposity, to components of cognitive control function. The data described in that chapter suggest differential associations between body composition, aerobic fitness, and cognitive control in a large sample of preadolescent children. Chapter 6 described a very small, yet growing literature-base on the relation of physical activity and fitness to cognition in children with developmental disorders, including attention deficit hyperactivity disorder and autism. Although more research is needed to grow this area of study, the findings suggest that both single bouts of physical activity and chronic activity participation may be effective non-pharmaceutical intervention approaches for childhood developmental disorders. Finally, Chapter 7 provided a quantitative and qualitative review of the relation of physical activity to scholastic performance. No research focus in this area of study is more topical or has received more attention. Thus, Chapter 7 was written to provide an update of the findings and shape future research efforts. Overall, the available evidence suggests that physical activity and greater amounts of physical fitness enhance scholastic performance, including both learning and achievement.

FUTURE DIRECTIONS

Moving forward, the body of work described in this monograph is suggestive of a mind–body relationship. However, understanding the nuances of such a relationship is critical toward understanding how to optimize brain health, cognition, and learning among children (and across the lifespan). To this end, continued research is sorely needed. A rich literature using non-human animal models exists that describes not only changes in brain structure and function that lead to improve learning and cognitive performance, but also selective cellular and molecular adaptations that occur in response to exercise (Gomez-Pinilla & Hillman, 2013). Continued mechanistic work is

necessary; however, this area also must extend to the realm of development, as the vast majority of research has focused on mature animals.

In children, we have only begun to “scratch the surface” of what is known. Future avenues for research are wide open. Although there is a definite place for correlational studies prior to enacting more costly intervention studies, there is a strong need to provide causal evidence. This is not as easily accomplished as it appears. That is, increasing physical activity and/or fitness to determine the relationship with brain and cognition is easily accomplished with the necessary resources. However, to fully understand this relationship, complete manipulation is necessary, meaning that scientists should also seek to decrease physical activity and/or fitness to investigate maladaptive effects on brain health and cognition; but such a study is unethical as it has the potential to be detrimental toward childhood health. A similar conundrum may be found in the examination of childhood obesity with brain and cognition, where intervention studies can be designed to reduce adiposity, but not increase it. Thus, future research will need to be creative in designing experiments that allow us to make small gains in understanding this relationship while maintaining ethical standards.

Other, more easily obtainable, future directions also require scientific inquiry. At present, we do not yet have a complete grasp of the extent of cognitive functions (or brain structures supporting them) that are influenced by markers of health behaviors. Findings in the area of cognitive control (particularly inhibition) and memory appear consistent and robust, but other areas remain less thoroughly studied or unexplored. Further, few of these findings have been translated out of the laboratory and into a “real-world” setting such as the educational environment. Relatedly, nearly all studies have focused on cognitive performance, with virtually no research on the actual process of learning in children (see Raine et al., 2013, for an exception). As described in Chapter 7, the vast majority of study within the educational environment has sought to understand the relation between physical activity or fitness on standardized achievement test performance. Unfortunately, it has not been determined whether these measures have the requisite sensitivity to capture the small, but positive relation of physical activity on cognition (Etnier et al., 1997). Thus, future research must venture outside of standardized achievement tests to investigate the relation of health markers to measures of cognition and learning, which are appropriate reflections of the educational environment.

CONCLUSION

In conclusion, this monograph describes a young, but growing area of study that is focused on understanding the role of physical health markers

that relate to cognitive and brain health. The overall focus of this line of research is to increase cognitive health and effective functioning during development, with the potential to increase lifelong brain health. Implications for this area of study relate to better scholastic performance and learning, which stands to contribute to individuals' cognitive reserve, improve vocational opportunities, and promote lifelong health and function. Although future research efforts are needed to increase our understanding of this relationship, the findings described in this monograph provide the foundation for these future research efforts through description of physical health-related changes in brain structure and function, cognition, and scholastic performance. Given that the outlook for childhood health has forecasted a continued decrease in the future (Fontaine, Redden, Wang, Westfall, & Allison, 2003; Olshansky et al., 2005), it is imperative that researchers continue to seek new and innovative means to improve not only physical health, but cognitive and brain health as well.

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