



Review Article

The relationship between physical activity and diet and young children's cognitive development: A systematic review

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ABSTRACT

Objective. Given the high prevalence of suboptimal nutrition and low activity levels in children, we systematically reviewed the literature on the relationship between physical activity and dietary patterns and cognitive development in early childhood (six months to five years).

Methods. In February 2016, we conducted two different searches of MEDLINE, PsycINFO, and ERIC. Each search included either physical activity (including gross motor skills) or diet terms, and neurocognitive development outcome terms. Included studies were in English, published since 2005, and of any study design in which the physical activity or diet measure occurred prior to age five.

Results. For physical activity, twelve studies (5 cross-sectional, 3 longitudinal and 4 experimental) were included. Eleven studies reported evidence suggesting that physical activity or gross motor skills are related to cognition or learning. Both acute bouts and longer term exposures showed benefit. For diet, eight studies were included consisting of secondary analyses from longitudinal cohort studies. A healthier dietary pattern was associated with better cognitive outcomes in all studies, although some of the reported associations were weak and the measures used varied across the studies.

Conclusions. Physical activity and healthy diets in early childhood are associated with better cognitive outcomes in young children. The paucity of literature and the variability in the type and quality of measures used highlight the need for more rigorous research. Given that the early childhood years are critical for both obesity prevention and neurocognitive development, evidence that the same healthy behaviors could promote both should inform future interventions.

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1. Introduction

Early life experiences shape a child's health and developmental trajectory. Increasing evidence suggests that obesity prevention needs to begin in early childhood because weight-related behaviors, such as food preferences and routine levels of physical activity, have early origins (McGuire, 2011). Unfortunately, many young children in the U.S. are not meeting dietary and physical activity recommendations, increasing their risk for obesity and obesity-related health conditions (Kranz et al., 2008; Reedy and Krebs-Smith, 2010; Beets et al., 2011; Sisson et al., 2009; American Academy of Pediatrics APHA, and National Resource Center for Health and Safety in Child Care and Early Education, 2012). Independent of weight status, poor diet and activity levels may also have consequences for children's current and future health and development. The early childhood years are a time for rapid and robust growth in cognitive development, but also a time of great vulnerability in this regard (National Research, 2000). Currently, limited evidence exists about the associations between children's diet quality, physical activity and cognitive outcomes. Although two papers were recently published describing activity and sedentary exposures and cognitive outcomes, additional reviews are warranted especially ones focused on both diet and activity (Carson et al., 2015a; Carson et al., 2015b). Thus, given the high prevalence of suboptimal nutrition and activity levels in children today and our limited knowledge of the effect on cognitive outcomes, a systematic review of the associations between physical activity, nutrition, and cognitive development in early childhood is needed.

Although the relationship between physical activity and cognitive development in young children is not well understood, there are at least three pathways through which aerobic (Carson et al., 2015b) exercise may facilitate cognitive functioning: (1) the acute cognitive demands of goal-directed and engaging exercise, (Kranz et al., 2008) the cognition required to execute complex motor movements, and (Reedy and Krebs-Smith, 2010) the short- and long-term physiological changes in the brain induced by aerobic exercise (Best, 2010). Compelling evidence exists in older children and adults that physical activity, particularly aerobic exercise and progressively challenging activities, and physical fitness, enhance cognitive performance (Hillman et al., 2009; Hillman et al., 2004; Fedewa and Ahn, 2011; Diamond and Lee, 2011a). Research among school-aged children has demonstrated that physical activity is associated with academic achievement and desirable classroom behavior (Trost, 2009; Welk et al., 2010; Carlson et al., 2008; Davenport, 2010; Mahar et al., 2006; Rasberry et al., 2011). Previous assumptions that younger children are sufficiently active along with the unique challenges of measuring both physical activity and cognitive

outcomes in early childhood may have limited the amount and quality of research in this age group.

Similar to physical activity, studies on animals, older children and adults have found that dietary factors influence cognitive processes and brain structure (Gomez-Pinilla, 2008). Studies in older children and adults have found that a higher intake of a "Western style diet" high in saturated fat and refined sugars can impair cognitive and academic performance possibly through its link to inflammation, oxidative stress, the gut microbiome and the involvement of the hippocampus (Jacka et al., 2015). The relationship between diet and cognitive development in young children however has largely focused on nutrient deficiencies, such as Vitamin B, which interfere with key cognitive processes. Although the role of specific nutrients is important, it is unclear if early exposure to overall unhealthy dietary patterns, which are low in nutrient-dense foods and high in added sugars and saturated fat, negatively impact children's cognitive development. It is plausible that healthier dietary patterns, which are rich in fruits and vegetables, lean proteins and whole grains may promote cognitive ability via changes to cellular processes, neuroplasticity, or epigenetic mechanisms, but it is also plausible that an unhealthy diet limits optimal neurological development (Bryan et al., 2004; Kussmann et al., 2010). In addition the high brain growth velocity during early childhood may be particularly sensitive to dietary factors (Isaacs et al., 2008). While the underlying physiologic mechanisms are being researched, understanding the relationships is important given that the typical diet of children globally is suboptimal, with calories typically coming from solid fat and added sugars, including high-fat milk, high-fat meats, cheese, grain deserts, fruit drinks, soda, and candy (Reedy and Krebs-Smith, 2010; Piernas and Popkin, 2011; Kiefte-de Jong et al., 2013; Lazarou et al., 2009; Malik et al., 2013; Alexy et al., 2011). Since children consume combinations of foods and nutrients, it is important to investigate the relationship of dietary patterns more broadly with regard to cognitive outcomes.

Given that early childhood is a formative developmental period, this study addresses important knowledge gaps by systematically reviewing the current literature on the relationship between physical activity and dietary patterns with cognitive outcomes in early childhood (6 months to five years).

2. Methods

This systematic review followed the PRISMA guidelines and the details of the protocol were registered on PROSPERO which can be accessed at <http://www.crd.york.ac.uk/PROSPERO/> (Registration No. CRD42015025116) (Moher et al., 2009).

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