NUTRITION & ACADEMIC PERFORMANCE

By **Christen Cupples Cooper, EdD, RDN**

In today's nutrition environment, many consumers seek not only foods and dietary supplements that enhance physical health and well-being but also "brain foods" that enhance cognition, mental acuity, and emotional well-being. The brain is the body's control center, and, as articulated by Rosales and colleagues in ***Nutritional Neuroscience*** in October 2009, what we eat matters when it comes to brain development and cognition.

It stands to reason that school performance, including cognition (ie, a complex set of higher mental functions the brain carries out, such as memory, thinking, learning, and perception), is impacted by diet, as described by Nyaradi and colleagues in the March 2013 issue of ***Frontiers in Human Neuroscience***. The authors review the growing body of literature on the links between nutrition and brain function. They assert that the period of most rapid brain development is the early years of life, and thus nutrition during childhood can set the stage for brain function over the lifespan. Although this article won't focus on maternal diet, a woman's nutrition status and dietary intake during pregnancy and lactation also can play roles in fetal brain development.

RDs also report academic success in clients with improved dietary quality. Marci Lerman Serota, RDN, CNSD, LDN, author of ***Hungry for Solutions: A Mother's Quest to Defeat Hypothalamic and Childhood Obesity***, says: "Since replacing most of the sugar and processed food in my clients' diets with nature-made food [and nutrients] such as vegetables, nuts, and protein, their teachers are reporting increased focus, less falling asleep in class, and a decrease in behavioral interruptions. I see this in my own children as well."

Drewnowski and Specter state in an article published in the ***American Journal of Nutrition*** in January 2004 that limiting intake of unhealthful foods is just as important for children's cognition and school performance as eating plenty of nutritious foods. A diet replete in low-nutrient foods leaves little room for calories from more nutrient-dense foods such as fruits and vegetables. And such a diet is hardly uncommon in children; in the ***Morbidity and Mortality Weekly Report*** of August 8, 2014, Kim and colleagues studied 2003–2010 National Health and Nutrition Examination Survey (NHANES) 24-hour dietary recall data from children aged 2 to 18 and found that no age group met the recommendations for vegetables, and children in only one age group (2 to 5) met fruit recommendations.

There's more bad news. Reedy and Krebs-Smith analyzed data from NHANES 2005–2006, publishing their findings in the ***Journal of the Academy of Nutrition and Dietetics*** in October 2010. They found that the top sources of energy for children aged 2 to 8 were grain-based desserts, pizza, and soft drinks, all of which contain many "empty calories" from solid fat and added sugars. Furthermore, calories from nutrient-poor foods represented nearly 40% (798 kcals/day) of children's total calorie intake (2,027 kcals/day).

Coupling these findings with data on the growing rates of childhood overweight and obesity generates increased concern for what children are eating and how food affects overall health and, of course, academic performance. In fact, excess weight itself may lead to cognitive problems.

Overweight and obesity in children are associated with impairments in executive function, including working memory, attention, mental flexibility, and decision-making, according to a review by Liang and colleagues published in the ***International Journal of Obesity*** in April 2014.

In addition, imaging studies have shown structural changes in the brains of children with excess weight. Convit and colleagues reported in the August 2014 issue of ***Obesity*** that obesity and metabolic syndrome, insulin resistance, low HDL, and abdominal fat were associated with lower academic scores, thinner orbitofrontal and anterior cingulate cortices, less white matter integrity, and reduced hippocampal volume.

Food Insecurity

Ample evidence suggests that students who face food insecurity (ie, an overall lack of enough food or enough nutritious foods to sustain good health) at home tend to have less favorable academic outcomes than their better-nourished peers.

Alaimo and colleagues reported in their May 2001 article in the ***American Journal of Public Health*** that food insecurity can lead to a cascade of poor outcomes, including higher susceptibility to illness, headaches, and stomach aches, all of which can contribute to school absences, lower academic performance, adverse social and psychological issues, as well as overweight and obesity.

In their review of the literature on kindergarten and third-grade children in the August 2016 issue of ***Journal of Nutrition***, Zhang and colleagues found that food-insecure children experienced smaller increases in both reading and mathematics performance than those children who were more food secure, suggesting that a lack of access to nutritious foods can impact learning. Bellisle and colleagues, in a study published in the ***British Journal of Nutrition*** in October 2004, reported that providing protein and carbohydrates, particularly glucose, to children who previously lacked sufficient food access improved cognition, concentration, and energy levels.

Importance of Healthful School Food

The Healthy, Hunger-Free Kids Act of 2010 brought school meals in line with the Dietary Guidelines for Americans for the first time. The law requires schools participating in the School Breakfast Program and National School Lunch Programs to increase offerings of whole grains, fruits, and vegetables; limit milk to lower-fat varieties; and serve meals within specific calorie ranges.

According to the USDA's Nutrition and Meal Cost Study published in April 2019, the mean Healthy Eating Index (HEI) score for National School Lunch Program lunches rose 41% between the 2009–2010 and 2014–2015 school years from 57.9 to 81.5 points out of 100, based on samplings of school lunch menus. The HEI score for school breakfasts also increased 44% during this time, rising from 49.6 to 71.3 out of a possible 100 points. The report states, "This finding suggests that updated nutrition standards for school meals have had a positive and significant influence on nutritional quality." An initial uproar over the more nutritious options seems to have subsided, with reports of generally steady and growing program participation rates nationwide, according to a study by Vaudrin and colleagues published in the ***American Journal of Public Health*** in January 2018.

Recognizing that many children receive a large proportion of their daily nutrient intake from school food and that total diet quality seems to impact school performance, Anderson and colleagues compared test scores of students at California public schools contracting with food vendors committed to minimally processed, nutrient-dense meals vs students at schools with typical vendors. Their findings, published in the ***Journal of Public Economics*** in December 2018, showed that students at schools with more healthful food scored 0.03 to 0.05 standard deviations (about 4 percentile points) higher on end-of-year academic tests compared with peers at schools with poorer-quality food. The improvements in test scores were 40% higher for students receiving reduced-price or free school lunches—those from families most likely to be food insecure and also most likely to eat school lunch.

Furthermore, the authors' analysis showed that, when comparing the cost of meal improvements with that of decreasing class sizes, upping nutritional quality won in terms of cost-benefit ratio. While reducing class sizes in kindergarten through third grade by one-third correlated with a greater test score increase (0.22 standard deviations) vs improving nutrition, better nutrition would cost around $80 per student per year compared with $2,000 per student per year for decreasing class size.

In a similar study, Belot and James compared nutritionally overhauled schools in Greenwich, United Kingdom, with control schools that still used typical vendors. Their findings, published in the ***Journal of Health Economics*** in May 2011, included significantly higher English and science scores at the intervention schools compared with the control schools. Authorized absences due to health conditions fell 14% in the experiment group schools.

Other school food programs such as the Universal Free Breakfast (UFB) program, part of the School Breakfast Program, may be able to assist students who come to school hungry by filling in nutritional gaps, leading to more energy to learn and better cognition. Kleinman and colleagues studied a pool of 97 children in the Boston Public Schools' UFB program to observe whether food intake affected academic performance. The study, reported in the ***Annals of Nutrition and Metabolism*** in February 2002, tracked students for the six months preceding the start of the program until six months after participation in the program. They found

that the UFB program increased nutrient intake and cognitive function while decreasing absenteeism.

A Minnesota study by Wahlstrom and Begalle published in ***Topics in Clinical Nutrition*** in December 1999 reported that a pilot of the UFB program improved concentration and alertness among children. Reddan and colleagues reported in the ***Journal of Nutrition Education and Behavior*** in January-February 2002 that schools with UFB programs reported having students with more energy and better attention than schools without such programs. Several other studies point to UFB programs as key to providing valuable nutrients and energy for learning.

According to Stephanie Simms Hodges, MS, MPH, RDN, founder at The Nourished Principles in the Charleston, South Carolina, area, "Nutritious school meals are as important for children as textbooks, school supplies, and transportation. The nutrition standards for school meals are extremely important for the many children across the United States who rely on school meals as their sole source of nutrition. Ensuring nutrition standards remain strong in school nutrition programs should be a priority for every school staff member including superintendents, principals, and teachers."

Healthful Fats and Brain Development

Nyaradi and colleagues state that the brain reaches about 80% of its adult weight by age 2 and, thus, early childhood is an important time for synaptic development. Different brain areas develop at different stages, and each area corresponds to cognitive functions such as language, reading, and memory. In the March 2006 issue of ***Trends in Neuroscience***, Toga and colleagues explain that the parts of the brain responsible for simpler functions develop first. Later, regions such as the frontal lobes, which control higher functions such as planning, sequencing, and self-regulation, develop. The growth happens again between 7 and 9 years and again at around 15 years. The basal ganglia, amygdala, and hippocampus, which are responsible for functions such as memory, emotion, and executive functions, develop into adolescence. The brain's white matter continues to develop beyond age 20.

With the brain composed of 60% lipids, healthful fats are important for brain development. Nyaradi and colleagues state that essential fatty acids play an important role as actual components of brain matter, but they also help to keep membranes fluid, facilitating receptor and enzyme activities and affecting ion channels. In addition, they influence inflammation and immunity, affect neural transmission and signal processing, and even regulate gene expression in the brain.

Bradbury, in an article published in the journal ***Nutrients*** in May 2011, provides evidence that modern humans' more advanced brain development relative to that of their ancestors may have been assisted by living near waterways, where fish and seafood were abundant. Bradbury and others point out, however, that over the past 150 years the balance of omega-6 to omega-3 fatty acids in the diet shifted to favor omega-6 in a ratio of 20:1 to 25:1. In other words, humans may not be getting the richness of omega-3s that our brains need for optimal growth, development, and cognition.

Several studies suggest that maternal fish intake during pregnancy can produce positive cognitive outcomes in children. Findings from studies by Hibbeln and colleagues, published in ***Nutrition and Health*** in July 2007, and Oken and colleagues in ***The American Journal of Clinical Nutrition*** in September 2008, suggest that higher maternal fish intake during pregnancy and lactation is associated with higher language and social skills, higher IQ, and more positive behavior in their children. On the other hand, studies on maternal supplementation with omega-3 have produced inconclusive results.

The same kind of conflicting results hold true for omega-3-rich diets and supplementation in children, including the addition of long-chain polyunsaturated fatty acids to infant formula. However, some studies suggest that omega-3 supplementation may help to improve visual and motor functions in children with phenylketonuria and aid in the management of childhood psychiatric disorders, according to a review of the literature by Ryan and colleagues in the April-June 2010 issue of ***Prostaglandins, Leukotrienes & Essential Fatty Acids***. A study by Milte and colleagues published in the ***Journal of Attention Disorders*** in November 2013 found that omega-3 supplements high in EPA, DHA, or linolenic acids improved attention and literacy and decreased oppositional behavior, hyperactivity, and cognitive problems in children with ADHD.

There are several other nutrients, such as iron, that play key roles in cognition. Iron deficiency in children can affect dopamine transmission and therefore impact cognition. As researched by Sorhaindo and Feinstein in a 2006 study for Wilder Research, other vitamins and minerals, especially thiamine, vitamin E, vitamin B, iodine, and zinc also are important for healthful cognition. Carbohydrates, which assist in the absorption of the amino acid tryptophan (which becomes serotonin), are important to cognition as well. Deficits in any of these nutrients may require dietary changes, supplementation, or both, at the discretion of a child's health care provider.

Nutritious Foods Reign

According to several reviews of the current literature on nutrient supplementation, such as that offered by Taras in the August 2005 issue of the ***Journal of School Health***, there's no evidence for making populationwide supplementation recommendations beyond customary guidelines for infants and young children, except in the case of therapeutic use or diagnosed deficiency. Research on micronutrient and macronutrient supplementation, including multivitamin use, is still largely inconclusive, and the effects of supplements likely vary by an individual's age, preexisting health conditions, genetic makeup, normal dietary levels of a nutrient, synergies between various foods in the diet, and other factors.

Overall, the research still points to a diet rich in a wide variety of minimally processed foods from all major food groups as the best route to positive, healthful brain development, general cognition, academic performance, and overall good health.

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