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Better Academic Performance: Is Nutrition the Missing Link?
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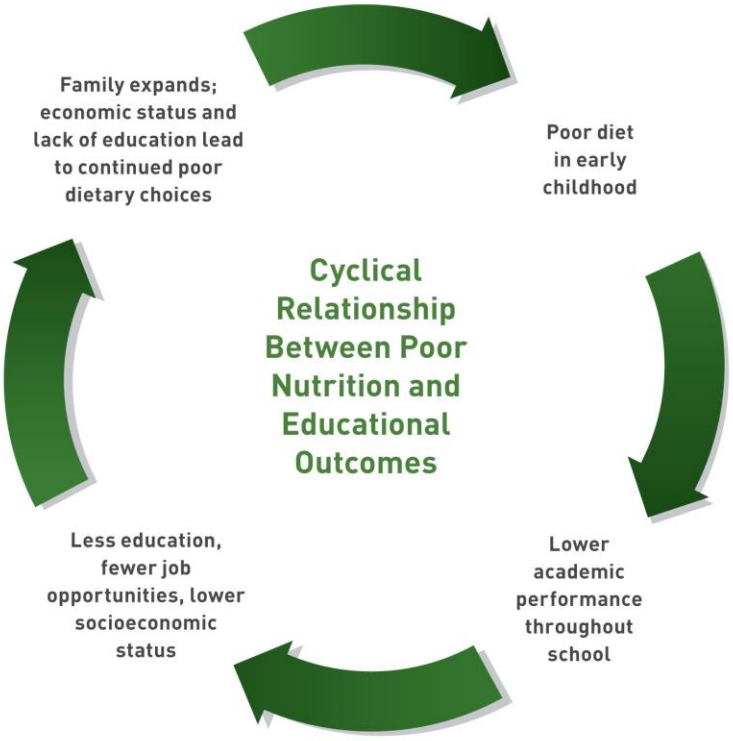
Education-Related Concerns

Given the amount of wealth and resources in the United States, it's surprising that the country doesn't lead in academic performance. Instead, compared with other countries with similar economic development, the United States ranks as average in reading and science and below average in mathematics.[3] In addition, often there are staggering differences in academic achievement within the country when comparing areas of high socioeconomic status with areas of low socioeconomic status.[4]

While there are many reasons for these differences, it's plausible that the Western diet may be one contributing factor. And since better academic achievement can lead to better job opportunities, housing situations, and access to health care, a poor diet in childhood may result in more serious problems down the line. It also may create a cyclical pattern in future generations, particularly in areas of low socioeconomic status where other compounding issues are present.[5]



Because academic performance influences future health, it's an important public health issue. It's also important to assess what nutrition factors most influence academic performance and how to improve them.

Breakfast

A regular, balanced breakfast offers many health benefits for children, including ensuring that they consume adequate calories to support growth and providing a variety of vitamins and minerals to prevent deficiencies. School breakfast programs have been shown to improve nutrition status among students who are considered to be at nutritional risk.[6,7]

Health isn't where breakfast's benefits end, though. Of all the topics examined in this course, the relationship between breakfast and academic performance has been the most researched. Breakfast consumption has been shown to enhance academic performance by improving cognitive functions such as memory and neural efficiency,[8-10] and school breakfast programs have been shown to reduce absenteeism and tardiness.[7,11]

Frequency of Breakfast Consumption

Studies of school breakfast programs have provided insight into the effects of regular breakfast consumption, particularly those studies that looked at implementing new breakfast programs. Meyers and colleagues compared one school district's standardized test scores before and after school breakfast implementation. Participation in the school breakfast program was associated with decreased tardiness, reduced absenteeism, and significantly greater increases in standardized test scores compared with nonparticipation.[11]

Another study looked at the implementation of a universal breakfast program and found that children who participated in the program were more likely than others to improve their nutrition status. Those children with improved nutrition status experienced decreased hunger, reduced absenteeism, and increased math scores.[7]

Such results generally aren't limited to school breakfast programs, although the improved attendance and reduced absenteeism may be specific to them. Students who eat breakfast regularly, regardless of location, likely are to see academic benefits, as many cross-sectional studies have demonstrated an association between overall breakfast frequency and better academic performance.[8,9,12-15]

A large study in Korea examined breakfast consumption among more than 75,000 students in grades 7 to 12. Male students who ate breakfast five days per week experienced improved academic performance compared with those who didn't eat breakfast. Among female students, positive associations were seen with as few as two breakfasts per week. With both sexes, eating breakfast every day showed the strongest odds of improved academic performance.[12] A smaller Korean study found that students who ate breakfast regularly had grade point averages that were 0.15 to 0.28 points higher compared with those who didn't eat breakfast regularly.[13]

Similar results have been found in studies in the United States. Among 800 sixth-grade students in North Dakota's Fargo Public Schools, for example, higher mean math standardized test scores were associated with students who ate breakfast more frequently.[14]

One Norwegian study looked beyond standardized testing and academic grades to view self-related subject difficulties as a measure of academic performance. Among the 475 high school students surveyed, those who ate breakfast regularly had a reduced risk of writing, reading, and mathematical learning difficulties.[15]

It's possible that breakfast's effects on academic performance are related to cognitive improvements, both in terms of a broader overall definition (eg, IQ) and in specific areas (eg, word recall, reaction time), each of which could improve learning ability and performance over time. For example, a cross-sectional study in China found that kindergarten students who ate breakfast often or always had higher IQs than did those who ate breakfast sometimes or rarely, and this persisted even after controlling for factors such as parental education and current living situation.[8] Other research has shown better performance on specific cognitive tests, including immediate memory recall, among breakfast eaters compared with breakfast skippers.[9]

Additional improvements in academic performance based on breakfast consumption may come from both nutritional and social factors. From a social perspective, children who eat breakfast regularly with their parents may experience improved communication and social development.[8] Vocabulary and comprehension skills also may improve as a result of regular family meals.[8] In addition, the children may be more likely to discuss school-related concerns or homework with their parents during these times.

Nutritionally, there are several mechanisms involved in improved academic performance. Breakfast serves to break the overnight fast and replenish blood glucose levels that a child's brain needs to perform well academically. Children's brains use more glucose than do adult brains,[16] indicating that regular breakfasts may assist brain function by providing the necessary level of glucose. Typical breakfast foods such as fruit, oatmeal, and whole wheat toast contain carbohydrates that increase glucose levels.[8]

Studies have shown that increased blood glucose levels can improve attention span, reaction time, and word recall.[17-19] Therefore, skipping breakfast may lead to difficulty concentrating, a shorter attention span, and memory problems.[18] Liu and colleagues present one possible explanation: "Glucose is the primary source of the acetyl groups that are used in the formation of acetyl CoA [coenzyme A], a precursor for the acetylcholine that regulates neurotransmission and benefits components of cognitive function, such as memory."[8] In addition, after eating, insulin and cholecystokinin levels increase, which is associated with "enhanced memory by means of neural activation and stimulation of the amygdala and hippocampus."[8] Also, the physical symptoms of hunger associated with not eating breakfast, such as headaches and stomach pain, can distract a student from learning in the classroom.

There are confounding factors that may challenge the strength of the association between breakfast and better grades. For example, more frequent breakfast consumption could be a

marker of better overall nutrition status among children, which may be the true link to better academic performance. It also could be linked to better socioeconomic status at home or other social factors. However, several studies have attempted to control for these confounders and have concluded that regular breakfast consumption does positively affect children's health and academic performance.[8,11-13]

Breakfast Type

Breakfast's effects on learning may be influenced by the type of breakfast a child consumes, not just the frequency or regularity of consumption. Some research has shown that lower-glycemic-index (GI) breakfast choices, those that don't result in a rapid initial increase in blood glucose, are associated with better cognitive outcomes. This is interesting considering the previously mentioned research showing an association between increased glucose levels and cognitive benefits such as memory and attention span.

However, the benefits from low-GI choices could be due to the slower and more sustained blood sugar response and fewer fluctuations in brain levels of glucose over a period of several hours.[20] This physiologic response to low-GI foods could improve students' ability to better concentrate during the several hours between breakfast and lunch, thus contributing to better academic performance.[18,20]

A few experimental studies have examined the impact of GI ratings of food choices on cognitive tests. Mahoney and colleagues looked at the effect of three different breakfast options—ready-to-eat cereal, instant oatmeal, or no breakfast—on the results of cognitive tests among elementary school children. Among children aged 9 to 11, eating either the cereal or oatmeal breakfast enhanced cognitive performance compared with no breakfast, but the oatmeal had additional benefits compared with the ready-to-eat cereal. Boys and girls had enhanced spatial memory, and girls also had improved short-term memory when they ate oatmeal. The same results were found when looking at children aged 6 to 8, and these younger children also showed better auditory attention.[18] A similar study of adolescents aged 12 to 14 found improved response times on two cognitive tests, the Stroop and Flanker tasks, which evaluate cognitive processing speed, choice reaction time, and selective attention, with a low-GI breakfast compared with a high-GI or no breakfast.[21]

Other research has examined the impact of different GI choices on the results of cognitive testing at regular time intervals throughout the morning. In experimental trials, children who were given a low-GI food choice for breakfast showed less cognitive decline over time compared with those given a high-GI choice.[22,23] While not all research has shown a connection between the GI and improved cognitive function,[24] most supports an association between low-GI breakfast choices and better cognitive performance. It's logical to postulate that the improved cognitive performance could be responsible for better standardized testing scores and grades over time.

In addition to the GI of food choices, overall breakfast quality has been shown to influence academic performance, with higher-quality meals associated with better grades.[25] One way of assessing breakfast quality is to look at the number of food groups eaten. For example,

Herrero and colleagues divided students into groups based on their breakfasts using the following categories:

• good quality (contained food from each of the dairy, grain, and fruit groups);
• improvable quality (lacked one of the three groups);
• insufficient quality (lacked two of the three groups); and
• poor quality (no breakfast).

There was a significant increase in students' average grades at the end of the year as the quality of their breakfasts increased.[26] These results suggest that parents and schools should be encouraging any breakfast consumption, regardless of the food choice, since any breakfast is better than no breakfast.

For families and schools that want an additional impact on academic performance, focusing on lower-GI breakfast foods and a complete breakfast that includes a few different food groups would be ideal. These choices may improve cognitive measures such as memory and attention, and may impact academic performance throughout the school year.

It's important to keep in mind, however, that the blood sugar response to a food depends on several factors, including portion size, how the item is cooked or prepared, and the other foods served with it. It isn't essential to cut out all high-GI breakfast foods but rather to incorporate them into balanced, portion-controlled meals combined with lower-GI foods. Examples of good breakfasts that both parents and schools can provide include the following:

• low-fat yogurt topped with whole grain cereal and fruit;
• vegetable omelet and milk;
• tomato, avocado, and cheese on whole wheat toast;
• whole grain, low-sugar cereal with milk and a piece of fruit;
• steel-cut oatmeal with sliced apples, cinnamon, and nuts; and
• a piece of string cheese, a piece of fruit, and a handful of pumpkin seeds.

Sugar-Sweetened Beverage Consumption

Sugar-sweetened beverages are a significant source of calories among both children and adults. From 2009 to 2010, children aged 2 to 19 consumed an average of 8% of daily calories from sugar-sweetened beverages, totaling an extra 155 kcal/day.[27] Soda is the No. 1 source of added sugar in children's diets, followed by fruit drinks.[28] Many of these beverages don't provide nutrients that support children's growth and development, and some, such as sodas and energy drinks, may provide potentially detrimental substances such as caffeine and certain herbal stimulants.[29,30]

There has been less research on the relationship between sugar-sweetened beverages and academic performance than there has been for some other dietary components. Studies focused on the immediate effects of sugar on cognitive performance, rather than on overall consumption, have revealed little evidence to support any negative associations. For example, a meta-analysis conducted in 1995 examined studies of sugar on behavior and cognition.[31] Studies were eligible for inclusion if they had a double-blind design, with one group consuming

a known amount of sugar and the other consuming a placebo substance; sixteen reports met inclusion criteria. For all of the 14 measurement constructs examined, including scores on neuropsychological tests, motor skills, and academic tests, sugar consumption didn't affect behavior or performance.

However, newer research looking specifically at soda consumption rates on overall academic performance has revealed different findings. Park and colleagues used data from the Youth Risk Behavior Survey to examine correlations between soda intake and academic performance in more than 16,000 students in grades 9 through 12. Drinking a soda at least once daily was associated with the increased likelihood of mostly B, C, or D/F grades compared with mostly A grades.[32]

Another study looked specifically at fifth-grade students, surveying 1,095 students in 11 elementary schools in Colorado. The authors found that drinking more than one soda each day was associated with reduced academic performance.[33]

One question that has arisen is whether such associations relate only to soda or to all sugar-sweetened beverages. One study compared all sugar-sweetened beverage consumption with academic performance among sixth-grade students and found that those who consumed fewer sugar-sweetened beverages had higher mean math and reading test scores.[14]

Future research focusing on both individual soda intake and total sugar-sweetened beverage consumption could provide valuable data and hopefully help narrow the potential reasons for these associations.

This research is interesting considering earlier studies found no relationship between sugar consumption and cognitive/behavioral variables.[31] The connection may seem counterintuitive since the brain needs a supply of glucose for memory and recall functions and sugar-sweetened beverages provide carbohydrates that affect glucose levels. However, as the breakfast research has demonstrated, lower-GI foods lead to a more sustained energy release over several hours, which may create a better glucose environment for the brain.[18,20-23] If sugar-sweetened beverages lead to a quick rise and fall of glucose levels, learning may suffer during the period when levels are dropping.

Along the same lines, other components of sugar-sweetened beverages, such as caffeine or herbal stimulants, could contribute to negative academic performance. Earlier experimental studies looked at sugar consumption vs a placebo but didn't look at other possible ingredients.[31] However, a recent cross-sectional study found that the consumption of caffeinated sugar-sweetened beverages was associated with stomach aches, headaches, and sleeping problems among youths aged 10 to 12.[34] Energy drinks, which have a higher caffeine content than cola, led to more pronounced side effects.[34] It's possible that children may perform less well academically as a result of these physical side effects of caffeine consumption rather than sugar.

Confounding variables also could skew the cross-sectional research. Sugar-sweetened beverage consumption may be a marker of a poor overall diet and has been associated with

other less healthful behaviors, such as getting fewer than eight hours of sleep per night and being sedentary.[32] Another possibility is that parents who allow their children to consume an excess amount of soda show less concern about their children's health, wellness, and academic performance. A variety of other factors, such as parental education, parental IQ, and socioeconomic status, could contribute to the relationship as well.

Though the research on the academic implications of sugar-sweetened beverage consumption is limited, it seems prudent to recommend keeping low the number of such beverages that children and adolescents consume. Even if the demonstrated relationships are due to another factor, from a health standpoint, the recommendation falls in line with the current dietary guidelines to limit added dietary sugars.

Fruit and Vegetable Intake

Fruit and vegetable consumption is another area that has been explored for its impact on academic performance. Current fruit and vegetable intake is less than ideal among children, and this is true even among school lunch participants, where fruits and vegetables are offered and/or provided as part of the meals. Plate studies have indicated that 55% of elementary school students and 66% of middle school students didn't select a vegetable as part of their lunch. In addition, students who chose vegetables and fruits left more than one-third of these items uneaten.[35]

While research currently remains limited, several studies have shown consistent associations between fruit and vegetable intake and better academic performance.[36-39] Among junior high and high school students in three studies, inadequate fruit and vegetable consumption was associated with poor academic performance.[36-38] One was a cross-sectional study conducted in Iceland that collected data on fruit and vegetable consumption, among other dietary variables, on 5,810 school children.[38] Academic achievement was assessed using self-reported data on grades, and the strongest association for any dietary variable and high grades was fruit and vegetable intake.[38]

Only one study has looked at fruit and vegetable consumption among elementary school students. Researchers in Nova Scotia surveyed 5,200 fifth-grade students and their parents. The researchers collected information on dietary intake and compared it with results of a literacy test. Students with higher fruit and vegetable intake were less likely to fail the literary assessment than were students with lower intake.[39]

As with other factors, the exact relationship between fruit and vegetable intake and academic performance remains unknown. However, there are many potential explanations. Nutrients in fruits and vegetables help protect the body from infection and/or reduce the risk of nutrient deficiencies, which could lead to fewer missed days of school and more time spent learning.[40-43] Fruits and vegetables also provide fiber to prevent constipation, which may distract children from learning because of discomfort and crankiness.[44-45]

In addition, since children's stomachs are smaller, they often need snacks in addition to meals to provide adequate nutrients and energy to support growth and development.[46] It seems reasonable to believe that snacking on fruits and vegetables during the day may alleviate

hunger and provide a healthy boost of energy, potentially helping to increase children's focus on schoolwork or homework.

Diet Quality

Diet quality refers to the overall composition of an individual's eating patterns or a generalization of how healthful the diet is rather than looking at one specific food or nutrient.[47] For example, one study used a food-frequency questionnaire and determined a diet quality score with the Diet Quality Index-International. Among 5,200 fifth-grade students, those with poor overall diet quality were more likely to perform poorly on a literary assessment.[39]

Compared with students in the lowest tertile of diet quality, those in the second and third tertiles were 26% and 41% less likely to fail the literary assessment, respectively. After adjusting for sex, parental income, education, and the particular school attended, students in the second and third tertiles still were 18% and 30% less likely, respectively, to fail the literacy assessment compared with those in the lowest tertile.[39]

Variety and adequacy were the diet quality index components most significantly associated with better academic performance compared with moderation and balance. The authors defined adequacy as "intake of foods and nutrients essential to a healthy diet such as fruits, vegetables, grains, dietary fiber, protein, iron, calcium, and vitamin C."[39]

Two other studies on diet quality took a somewhat different approach, assessing poor diet using a clustering of several junk foods. In the first, the variable of poor diet was assessed based on how frequently the student consumed five foods: sweets, chips, French fries, hamburgers or hot dogs, and pizza. Among the 5,810 ninth- and 10th-grade students, there was a significant negative correlation between poor diet and good grades.[38]

In the second study, a poor diet was represented by high consumption of "sugar-sweetened soft drinks, sweets, chocolate, savory snacks, pizza, and hot dogs." The study found that a high intake of these foods was associated with increased mathematical difficulties.[15]

Thus, the available literature suggests a possible association between overall diet quality and academic performance. However, it's an area that deserves more research, as only a few authors have examined this association.

The ways in which diet quality influences learning have yet to be firmly identified, but several theories exist. Diet quality may influence energy balance and micronutrient intake, which are important factors in overall health and academics.[48,49] Poor diet quality may be a marker of food insecurity and hunger, which can cause physical symptoms that interfere with learning.[49,50] Poor-quality diets may lack certain nutrients, such as iron and zinc, which play a role in brain development, cognitive function, and behavior.[49,51,52]

Abundant Opportunities for Dietitians

Research has shown strong and consistent associations between breakfast consumption and better academic performance. Though the literature still is somewhat sparse for other health

behaviors, what's available suggests that diet quality, fruit and vegetable intake, and sugar-sweetened beverage intake may influence grades.

Schools may see health promotion and nutrition education activities as being lower priorities than core curriculum subjects, particularly with a growing focus on standardized testing and the No Child Left Behind Act. However, it's important for schools to realize that these are complimentary rather than conflicting priorities. Allocating time for nutrition education, incorporating health promotion into school activities, and improving school breakfast and lunch offerings are ways to improve children's health and academic performance.

There are many unique avenues for RDs to become involved in promoting school wellness, including the following:

• **Look for job opportunities or consultant work** in a school foodservice department to try to improve the nutritional value of the foods offered. Help develop a menu that's both appealing and nutritious for children.

• **If working with schools, explore participation** in the USDA Fresh Fruit and Vegetable Program. This federally funded program provides schools with money to purchase fresh fruits and vegetables that are served as snacks during the school day. Research has shown increased fruit and vegetable intake among students in participating schools.[53]

• **Act as a consultant for a school district** to assist in the implementation of new federal or state legislation related to nutrition, such as the Smart Snacks in Schools nutrition standards. Issued in June 2013, these standards create new regulations for competitive foods sold in schools, including those in vending machines, and set limits for calories, sugar, fat, and food type.[54] Since vending machines typically contain poor-quality foods and sugar-sweetened beverages,[55] this new legislation may improve students' nutrition in these two areas. Schools may need help interpreting and implementing these regulations, creating a perfect avenue for dietitians to approach them about consultant work.

• **Lobby for legislation** that supports nutrition and physical education in schools.

• **Develop and provide nutrition education programs** for students and parents to help improve nutrition beliefs and behaviors. Consider focusing specifically on nutrition topics that influence both health and academic performance. These may be done in schools, through community organizations, or through a private practice. Many activity suggestions have been provided in the RD Tip Sheet available at the end of this course. Also, the Kids Eat Right nutrition education presentations available through the Academy of Nutrition and Dietetics include a variety of topics and are available free of charge. Mini grant opportunities to give school and community presentations frequently are available through Kids Eat Right.

• **Assist with the development of core curricula** for schools that incorporate nutrition themes or provide training for teachers on nutrition curriculums that already are available, such as CATCH (Coordinated Approach to Child Health), Eat Well & Keep Moving, Planet Health, or Nutrition Detectives.

• **Create new, innovative nutrition curricula** for teachers, after-school programs, community programs, or parent workshops. They could be published and then marketed to schools and organizations.

• **Develop monthly nutrition posters/bulletin boards** for use at schools.

• **Write nutrition newsletters** that can be sent home to families.

• **Host grocery shopping field trips** for children, parents, and/or families. Consider asking whether the grocery store will sponsor your time.

• **Create a program to train peer nutrition educators** in schools. Teen educators can provide nutrition classes or tips to other students or just model healthful choices to influence habits. Research shows adolescents with friends who eat breakfast, whole grains, and dairy are more likely to eat these foods themselves.[56]

• **Create gardening programs** or cooking classes for children or parents.

• **Offer nutrition workshops** for student athletes to improve both academic and athletic performance through proper fueling.

If funding is an issue, look toward nontraditional routes for providing these services. For example, the school could create a donor project for nutrition education initiatives. Also, look into grant opportunities, work with private schools that typically have more flexibility in spending, or create after-school nutrition programs that charge a small fee for each student.

Moving Forward

The push for school nutrition initiatives traditionally has focused on health outcomes. While these certainly are important, it's time to shift the conversation to include the academic implications of dietary choices. It's clear that nutrition behaviors such as eating breakfast impact learning outcomes. Other behaviors, such as adequate fruit and vegetable intake, better diet quality, and lower consumption of sugar-sweetened beverages, are supported by a growing body of evidence for their role in academic performance.

By focusing on the link between good nutrition and improved success in the classroom, dietitians can strengthen their argument for better school foodservice and wellness initiatives.

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Examination

1. For which of the following dietary variables is there the strongest body of research supporting an association with academic performance?
A. Regular breakfast consumption
B. Sugar-sweetened beverage intake
C. Fruit and vegetable consumption
D. Diet quality

2. Breakfast both at and outside of school can influence academic achievement. In research, school breakfast programs were found to have some additional benefits, especially in low-income communities. Which of the following is a benefit specific to school breakfast programs?
A. Reduced absenteeism
B. Improved attention span
C. Better test scores
D. Improved nutrition status

3. A cereal with which of the following glycemic index values would be most likely to have the most beneficial impact on a student's cognitive function throughout the morning?
A. 50
B. 71
C. 87
D. 95

4. How many additional calories do children consume each day from sugar-sweetened beverages?
A. 125
B. 155
C. 185
D. 205

5. Based on this course, which of the following statements is true regarding the body of research on sugar-sweetened beverages and academic performance?
A. There's no evidence to suggest that sugar-sweetened beverages affect academic performance.
B. All available research supports an association between sugar-sweetened beverages and reduced academic performance due to the sugar content.
C. All available research supports an association between sugar-sweetened beverages and reduced academic performance due to the caffeine content.
D. Newer research suggests a link between sugar-sweetened beverages and reduced academic performance, but it's unknown if this is a true causal association.

6. To date, there's only one study that has examined the relationship between fruit and vegetable intake and academic performance among elementary school students. This study found that higher consumption of fruits and vegetables was associated with which of the following?
A. Higher GPAs
B. Increased grades in science classes
C. Reduced likelihood of failing a literary assessment
D. Reduced likelihood of failing a math assessment

7. Diet quality has been assessed in relation to academic performance using which of the following methods?
A. The frequency with which children eat certain junk foods
B. Blood levels of vitamins and minerals
C. Number of food groups eaten each day
D. Hair analysis

8. One way that diet quality may influence academic performance is by ensuring adequate intake of certain nutrients. Which two nutrients mentioned in this course influence cognitive function in children?
A. Potassium and sodium
B. Vitamin K and magnesium
C. Riboflavin and vitamin C
D. Iron and zinc

9. When approaching a school about working as a consultant, you mention that you can assist the school with implementing the new nutrition standards for competitive foods sold in schools. What is the name of this set of nutrition standards?
A. The Healthy Foods Act
B. National School Lunch Program
C. Smart Snacks in Schools
D. Modernization of School Foods

10. A friend's dietary habits can influence breakfast, whole grain, and dairy intakes among adolescents. Which of the following programs would you develop to use this information as part of its strategy?
A. Community gardening program for parents
B. After-school cooking class led by a dietitian
C. Peer nutrition promotion program
D. Foodservice breakfast promotion by cafeteria staff