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Breakfast and Adolescent Academic Performance: An Analytical Review of Recent Research

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Over the past several decades, researchers have suspected and confirmed various links between breakfast consumption and adolescent academic performance, although the reasons for these cognitive consequences are not fully explored nor understood (Dye & Blundell, 2002; Giovannini, Agostoni, & Shamir, 2010; Murphy, 2007). More specifically, it has not yet been determined precisely what roles various micro- and macronutrients play in the outcomes observed in students' academic behavior (Kleinman et al., 2002), though a positive relationship has been drawn between breakfast consumption and many cognitive abilities (Lamport & Woodhouse, 2012; Pollitt & Matthews, 1998). In a workshop given at the MilanoPediatria meeting, Giovannini, Agustonia, and Shamir (2008) noted that children who ate breakfast demonstrated improved problem-solving, short-term memory, attention, and episodic memory (Pollitt, Lewis, Garza, & Shuman, 1983; Vaisman, Voet, Akvis, & Vakil, 1996; Wesnes, Pincock, Richardson, Helm, & Hails, 2003) in comparison to those who did not eat breakfast, as well as better cognitive performance than breakfast skippers (Dye, Lluck, & Blundell, 2000). However, Giovannini et al. reported that "the exact reasons for these effects are not fully understood" (2008, p. 98). Yet, despite the lack of clarity in this field, it is becoming more and more evident that a healthy breakfast is beneficial to a student's academic success and deserves more in-depth study to determine the reliable correlations between breakfast foods and academic achievement (Florence, Asbridge, & Veuglelers, 2008).

With so much information still unknown regarding the specific links between breakfast foods and school performance, policy makers, educators, and parents must not only support regular breakfast consumption, but also seek to modify students' nutritional intake based on the most current research available in the field. Breakfast consumption is a global and costly issue, requiring the attention of policy makers to determine the best use of funds and program implementations. Educators daily compete with a myriad of learning impediments in their classrooms, not the least of which is improperly nourished students who struggle with focus and knowledge retention. Parents, as some would suggest (Matthys, De Henauw, Bellemans, De Mayer, & De Backer, 2007; Ruglis & Freudenberg, 2010), may play one of the most important roles of all, as they set an example for their students in healthy eating and lifestyle habits. However, the question of *what* healthy eating habits best maximize learning remains unanswered. Florence et al. (2008) noted the impending need for

more study, suggesting that "in order to demonstrate the temporal sequence of the relationship, further longitudinal research examining diet quality and academic performance would need to be conducted" (p. 214). The case is by no means closed on the interrelated connections between breakfast nutrition and scholastic success.

The purpose of this literary review is twofold. First, the current research findings on the recommendations for healthy breakfast consumption are analyzed, including the foundational links between eating breakfast, greater nutrient intake, and overall improved academic performance. Second, the relationships between overall breakfast quality, the glycemic index/load of breakfast meals, and specific micro- and macronutrient consumption (iron and protein) with their impacts on cognitive abilities are explored as currently understood by experts in the field. The findings in this review will focus on the work of nutritional and governmental reports published since the 1980s, but will specifically highlight on the research of the past decade.

Organization of Literature Review

In order to form a commonly understood basis, several key terms will first be defined. After this introductory set of definitions, the background research supporting the need for breakfast – especially as related to academic performance, but also as related to health and nutrition – will be explored. Then, the components of a healthy breakfast as deemed such by experts will be analyzed, including data linking improved academic performance with specific micro- and macronutrients.

Key Terms

Used throughout the breadth of this literature review, several key terms need to be defined and commonly understood by readers as terms meaning the same thing. Variations to these definitions by individual research findings will be noted as needed.

Breakfast

In an article reviewing the literature published since the 1990s on the associations between breakfast and student outcomes, Murphy (2007) attempted to gather literature defining the concept of breakfast. Murphy (2007) noted that:

> *An "anything goes" approach to the definition of breakfast undermines the validity of the concept . . . in much the same way that allowing ketchup to be counted as a serving of vegetables undermines the recommendation that children eat five or more servings of vegetables a day. (p. 5)*

In Murphy's (2007) meta-analysis, McLaughlin, Bernstein, Crepinsek, Daft and Murphy (2002) reported that the most widely held definition agreed upon by the United States Department of Agriculture [USDA] is one that requires that breakfast to encompass "at least 10% of RDA for energy *and* food from at least 2 major food groups" (p. 19). Murphy (2007) clarified the USDA definition by explaining that outside the United States there are often stricter definitions of breakfast espoused that require the meal to total 20-25% of recommended daily allowance [RDA] for energy and include food from three food groups (p. 19). Murphy (2007) also noted that for school breakfast

programs the USDA requires that breakfast include "food from 2-3 groups and nutrients totaling =/> 25% of RDA for total calories, protein, and certain vitamins and minerals" (p. 19).

Giovannini, et al. (2010) explained the definition of breakfast from the view of experts outside the United States, demonstrating Murphy's (2007) point that some researchers hold more stringent standards than the USDA. In their symposium overview, Giovannini et al. referenced Timlin and Pereira (2007), defining breakfast as "the first meal of the day, eaten before or at the start of daily activities within 2 hours of waking, typically no later than 10:00 a.m." (p. 98). Timlin and Pereira (2007) further elaborated on the definition, requiring that the calorie level of breakfast be between 20% and 35% of RDA (as cited in Giovannini et al., 2010, p. 98).

From these definitions it can be gathered that the meaning of the term *breakfast* has not been standardized to researchers' satisfactions. Throughout this literature review, discrepancies in the use of the word breakfast will be noted if that discrepancy impacts the data being reported.

Food Groups

As demonstrated by several of the definitions for the term breakfast (McLaughlin et al., 2002; Murphy, 2007), the use of the phrase *food groups* is common in literature regarding breakfast consumption. According to the Centers for Disease Control and Prevention [CDC], recommended foods are categorized into either five or six major food groups depending on which traditional eating plan is being followed (2010, What are the major food groups?). The USDA's system, known under the taglines MyPlate and MyPyramid, categorizes all recommended foods into five major food groups, while the Dietary Approaches to Stop Hypertension [DASH] developed by the National Institutes of Health [NIH] categorizes all recommended food into six major food groups, adding a separate category for "Nuts, Seeds, and Legumes" that the USDA's recommendation does not contain (CDC, 2010, What are the major food groups?). According to the CDC, however, both eating plan guidelines are identified as healthy (2010, What are some examples of healthy eating plans?).

Although the USDA's recommendations are often more pertinent to the findings regarding breakfast consumption and academic performance due to the agency's close involvement in U.S. school breakfast programs, both primary guidelines will be outlined here since many research articles consider overall breakfast consumption as unrelated to school breakfast programs and may or may not follow the USDA recommendations. The DASH guidelines divide foods into the following six categories: (1) grains, (2) vegetables, (3) fruits, (4) fat-free or low-fat milk and milk products, (5) lean meats, poultry, and fish, and (6) nuts, seeds, and legumes (U.S. Department of Health and Human Services, 2006). Two food groups not mentioned by the CDC as recommended food groups, but still included on the DASH chart are (1) fats and oils and (2) sweets and added sugars (U.S. Department of Health and Human Services, 2006). The five recommended food groups published by the USDA ChooseMyPlate.gov website under the MyPlate tagline are (1) fruits, (2) vegetables, (3) grains, (4) protein foods, and (5) dairy (Choose a Food Group). According to the same USDA online resource site, "Oils are NOT a food group, but they provide essential nutrients. Therefore, oils are included in USDA food patterns" (What are "oils"? section).

If possible, the food group definition being used by the research presented in this literature review will be indicated, specifically if that information is pertinent to the findings being discussed.

Micro- and Macronutrients

Although the terms *micronutrients* and *macronutrients* are not often used anymore, for clarity's sake they will be briefly defined. According to P. A. Balch and J. F. Balch (2000):

> *Like water, carbohydrates, protein, and fats, and the enzymes required to digest them, vitamins and minerals are essential to life. They are therefore considered nutrients, and are often referred to as micronutrients simply because they are needed in relatively small amounts. (p. 5)*

P. A. Balch and J. F. Balch (2000) do not define macronutrients, seeming to assume that readers will understand that macronutrients include all foods that are not considered vitamins and minerals. According to the Food and Nutrition Board (2005), macronutrients include carbohydrates, fibers, fats, fatty acids, cholesterol, proteins, and amino acids. This definition from the Food and Nutrition Board (2005) is also cited on the online Interactive DRI Glossary: Food and Nutrition Information Center of the USDA National Agricultural Library. The Interactive DRI Glossary also backs-up P. A. Balch and J. F. Balch's (2000) definition of micronutrients as being vitamins and minerals.

The Need for Breakfast

Breakfast as the first meal of the day has been studied for its impact on health issues and academic performance. Beyond simply satisfying hunger, breakfast has been shown to improve both the health of and the cognitive abilities of individuals who consume the meal, specifically when it is composed of high-quality nutrients. For the purpose of this literature review, this section will be broken into two parts: (1) overall health benefits of breakfast, and (2) general academic performance improvements demonstrated by breakfast eaters.

Overall Health Benefits of Breakfast

Improved health and better academic performance are consequences of breakfast often studied together due to their closely linked nature; however, the two issues are worth looking at separately in light of the bearing each has on school-age children. In the meta-analysis by Murphy (2007), evidence documenting the link between breakfast consumption and academic performance was gathered and reviewed with specific emphasis on the data gleaned between the years 2000 and 2004. While much of this research pertains to a later section of this review specifically discussing academic performance, Murphy (2007) also took care to note the established association between eating breakfast and health. In the 2007 review, Murphy reported that "breakfast skipping has been shown to have a negative relationship to the intake of many if not most vitamins and minerals," (p. 19) as well as correlating with a higher consumption of dietary fat. Moreover, Murphy called attention to the influence that the type of breakfast foods have on the ensuing nutritional benefits to children. "Some traditional breakfast foods such as eggs and pancakes are higher in fat than breakfasts of ready-to-eat cereal, low-fat milk, and fruit," Murphy clarified (2007, p. 6). In addition to drawing personal conclusions and organizing strong unifying themes that have developed in the literature of the past several years, Murphy also evaluated many key sources that are mentioned in this literature review.

Murphy seemed particularly impressed with the work of Nicklas, O'Neil, and Myers (2004). According to Murphy (2007), Nicklas et al. wrote one of the best summaries of the impact of breakfast on nutrition, emphasizing that breakfast eating has a "substantial effect on the overall nutrient adequacy" (2004, p. 35) of children. Nicklas et al. (2004) also concluded that children who skip breakfast are at an increased nutritional risk due to the fact that the nutrients that were not consumed during breakfast were not usually replaced at later meals (Murphy, 2007). According to the 2004 study, specific nutrients that breakfast skippers were up to two thirds deficient of the RDA were vitamins A, B6, and D, calcium, magnesium, riboflavin, folacin, zinc, phosphorus, and iron (as cited by Murphy, 2007). Also cited by Murphy (2007) were two studies that indicated that breakfast skippers were more likely to show symptoms of iron-deficiency anemia (Abalkhail & Shawky, 2002) and the potential for a decrease in calcium intake, which appeared to be linked to the intake of milk often consumed at breakfast meals, but not consumed by breakfast skippers (Ortega et al., 1998). In general, it is also important to observe the correlation between the choice to eat breakfast and the choice to eat healthy foods throughout the rest of the day. Giovannini et al. (2010) drew attention to this fact, observing that "regular breakfast consumption is associated with improved diet quality and better food choices throughout the day" (p. 98). Overall, the total nutrient adequacy of children seems to be positively impacted throughout the day by the choice to consume breakfast.

As the benefits of breakfast are being reviewed, it is important to take note that the quality and caloric size of the breakfast in question are also being considered. Murphy (2007) cited a large European study by Serra-Majem et al. (2002) that "found that children and young adults who consumed a 'low-quality breakfast' were more likely to be at overall nutritional risk (i.e. lacking in key nutrients and micronutrients) than those who ate higher quality breakfasts" (p. 19). Although not explained by Murphy, after reviewing the details of this study of Spanish children, a meal with a high breakfast score was deemed by the researchers as one with at least one dairy product and a cereal or a fruit (Serra-Majem et al., 2002, p. 37). The caloric intake was not specifically mentioned. In another study of Parisian children (Preziosi et al., 1999), the caloric size of the breakfast was studied. According to Murphy (2007), Preziosi et al. (1999) found that children who ate breakfasts in either the caloric ranges of 15-25% or >25% of daily energy allowance reported higher total micronutrient intake than children who ate smaller breakfasts. Further examination of the study revealed that breakfast was loosely defined as "the first eating occasion involving a solid food or a beverage that occurred after waking" (Preziosi et al., 1999, p. 172); however, the type of breakfast was divided into categories based on the percent of the daily energy allowance consumed. These studies appear to point to the need for higher-caloric, more-balanced morning meals.

Also in support of the nutritional benefits of eating breakfast, but wary of the quality of breakfasts provided by U.S. schools, Kleinman et al. (2002) further found that children who participated in a school breakfast program showed overall improved nutrient intake. However, the researchers harbored concerns about the nutritional quality of school breakfast programs (Kleinman et al., 2002). In the discussion section of their findings, they acknowledged the seeming correlation between breakfast consumption and increased nutrient intake, but clarified the value of offering free breakfasts to students by noting that school breakfast programs offer "the potential for improved nutrient intake, decreased hunger and improved academic and psychosocial performance" (Kleinman et al., 2002, p. 29). As highlighted by the use of the phrase "potential for improved nutrient intake" (2002, p. 29) and other conclusions following their research, Kleinman et al.

supported the benefits of breakfast consumption, but were hesitant to defend the merit of traditional school breakfast programs without further study on the quality of the breakfast being offered.

On the topic of school breakfast programs, more research continues to go into the programs offered in U.S. schools. The Food Research and Action Center [FRAC] is one of the top non-profit organizations working in the U.S. to eradicate hunger and change public policies, including those effecting school breakfast programs. According to a 2011a FRAC report, school breakfast participants are more likely to consume adequate nutrients and are more likely to eat fruit and drink milk at breakfast. Crepinsek, Singh, Bernstein, and McLaughlin (2006) cited by the FRAC report noted that:

> *Students attending schools that offer a breakfast free to all students are more likely to consume a nutritionally substantive breakfast and to consume significantly more calcium, magnesium, phosphorus, fruit, and dairy products at breakfast, when compared to students from schools with a traditional means-tested school breakfast in the cafeteria program. (2011a, p. 2)*

This data is significant due to the implications that even those students who don't require free breakfasts based on socio-economic and financial status may benefit from the nutrients in a universally-free breakfast. According to FRAC (2011a), the breakfast in the classroom programs are a new alternative to the traditional cafeteria breakfast programs in which breakfast foods are either kept on a cart outside of first period classes or delivered in temperature-monitored containers from the cafeteria kitchen the night before. No matter which way the food is prepared, the result is that students eat breakfast during first period classes versus before school (FRAC, 2011a). This seems to increase the numbers of students partaking in the program due to the decreased stigmatism associated with free breakfast participation (FRAC, 2011a). The increased number of students consuming this regulated breakfast may improve the overall nutrient consumption of a wider basis of students, pointing to the overall nutritional benefit of school breakfasts despite some researchers' concerns (see Kleinman et al, 2002, for explanation of concerns).

General Academic Performance Improvements

For the purpose of this literature review, even more important than the overall health benefits of breakfast consumption are the academic benefits associated with breakfast consumption. Many studies have not broken down the quality and specific nutrient content of breakfast as tied to individual academic outcomes; however, those studies that do differentiate between nutrients will be addressed later. In this section, the background research and basis for breakfast consumption as related to overall academic performance will be evaluated.

In addition to studying the connection between breakfast consumption and overall health benefits as discussed previously, FRAC has also devoted much of their research to the superior academic performance demonstrated by breakfast eaters. According to FRAC (2011b), skipping breakfast impaired children's ability to learn, while eating breakfast improved student academic performance and behavior. More specifically, FRAC (2011b, p. 1) noted that breakfast skippers "are less able to differentiate among visual images, show increased errors, and have slower memory recall" (Pollitt, Cueto, & Jacoby, 1998). FRAC (2011b) also highlighted the enhanced cognitive abilities of

breakfast eaters, specifically pointing out that children who consume breakfast perform better on vocabulary tests and matching figures (Jacoby, Cueto, and Pollitt, 1996; Pollitt et al., 1998) and better during demanding mental tasks (Bellisle, 2004). Even more interesting, FRAC (2011b, p. 1) reported that, "Children who eat a complete breakfast, versus a partial one, make fewer mistakes and work faster in math and number checking tests" (Wyon, Abrahamsson, Jartelius, & Fletcher, 1997). The abstract for the Wynon et al. (1997) experimental findings defined a high energy breakfast (assumed to be referring to a "complete breakfast") as one which provided over 20% of recommended daily energy intake versus a low energy breakfast which provided less than 10% of recommended daily energy intake. Overall, the research provided by FRAC (2011b) supported the concept of improved cognitive function with the consumption of breakfast.

Along similar lines, Murphy (2007) compiled a thorough review of the current literature related to breakfast consumption and learning. In his discussion, Murphy (2007) theorized that eating breakfast provides short and long term energy that is available for cognitive processes during a school day. Murphy (2007) found that:

> *Their [breakfast skippers'] attention on some tasks may actually be better due to increased arousal but overall they probably have fewer cognitive resources available for memory and attention. They certainly have less energy. Given their lower level of energy, breakfast skippers may be somewhat easier to manage behaviorally but they have less energy available for learning. (p. 31)*

Kleinman et al (2002) also found that children with lower nutritional intakes had lower GPAs than children with "adequate intakes of both nutrients and energy" (p. 27-28). The findings of Kleinman et al. (2002) are particularly important because, as referenced previously, Nicklas et al. (2004) observed that students who did not consume adequate nutrients at breakfast did not usually replenish those nutrients during later meals. Therefore, students not eating breakfast may be at an increased risk of earning lower GPAs, yet have less energy available to improve their GPAs (Kleinman et al, 2002; Murphy, 2007).

Taras (2005) reported mixed findings regarding the correlation between learning and nutrition; however, the 2005 review did note that eating a healthy breakfast consistently improved the performance of undernourished students, as well as consistently improved various cognitive functions in the short term among student populations. Taras (2005) was concerned by the lack of standardization in breakfast trials, as well as the weak correlation that many of the studies' results may have to U.S. students. According to the Taras, "Food insufficiency is a serious problem affecting children's ability to learn, but its relevance to US populations needs to be better understood" (2005, p. 213). The reason for this assessment is the unproven nature of U.S. students' levels of nutrient insufficiency (Taras, 2005). However, Taras (2005) did find that offering a healthy breakfast to undernourished populations reliably improved academic performance. The researcher's concern rested more in the fact that "the long-term effects of eating breakfast on the performance of school children who do not have physical signs of severe undernourishment is less certain" (2005, p. 213). Yet, it is still important to understand that Taras' 2005 meta-analysis did *not* combat the idea that academic performance and nutrition were integrally related. Matter of fact, various studies analyzed in Taras' meta-analysis showed that among the skills that improved after breakfast was

consumed were “verbal fluency, arithmetic, tests of attention, memory, creativity, physical endurance, and general tests of academic achievement and cognitive functioning” (Taras, 2005, p. 213). As Dye and Blundell (2002) noted in their study of functional foods, “the principle that foods can reliably affect cognitive performance is receiving validation and experimental support” (p. S187); however, the authors clarified their assertion with the disclaimer that much of this research is still in a “relative state of infancy” (p. S187).

As perhaps best summarized by Giovannini et al. (2010), breakfast has both an impact on the health and the academic abilities of children. The fact that this theory has been so widely accepted can be seen in the widespread nature of school breakfast programs in the U.S. and in other countries. Murphy (2007) drew attention to this argument, noting that at the time of his primary research (2004-05) the “universal free school breakfast program were operating in more than two thousand schools. . . . These facts alone attest to the perceived success of as well as of the perceived need for such programs” (p. 10). However, this proof does not indicate that the research regarding the impact of breakfast should be discontinued. Rather, as Taras (2005) concluded, more research than ever is needed regarding the benefits of nutrition (particularly breakfast) on school performance, specifically in regards to the effects of individual nutrients on skills needed to perform well at school. The next section of this literature review will discuss some of the findings that more specifically pinpoint certain aspects of breakfast as associated with more explicit cognitive functions.

Components of a Healthy Breakfast as Related to Academic Performance

Despite the overall health and academic benefits of breakfast consumption demonstrated in the previous sections, the question from the introductory section of this review still remains: What healthy eating habits best maximize learning? Stated more succinctly, this question could be rephrased: What specific nutrients have demonstrated positive impacts on various cognitive functions? To restate Dye and Blundell (2002), much of this “domain of research is still in a relative state of infancy but also rapid development” (p. S187). As specifically pertinent to the scholarly community at this time, the “rapid development” (Dye & Blundell, 2002, p. S187) of scientists’ understanding of how nutrition affects various academic activities is worth examination and application in areas of policy, program implementation, and training. In this section of the literature review, the current research and findings that tie specific micro- and macronutrients to certain cognitive abilities will be analyzed. Also examined are the findings regarding the quantity/quality of breakfast as related to academic performance.

This portion of the review is divided into several smaller sections in order to categorize the wide variety of experimental findings. First, overall diet quality as related to academic performance will be examined. Then, the effects that the glycemic index and the glycemic load of breakfast will be reviewed in light of the correlations between these two aspects of nutrition and cognitive abilities. Finally, the impact of various micro- and macronutrients on children’s performances will be considered.

Overall Diet Quality

In contrast to the studies of the influences of individual nutrients on children’s academic performance, overall diet quality as a force effecting cognitive ability has also been investigated in a

groundbreaking study. In a 2003 survey of 5200 fifth grade students in Nova Scotia, researchers Florence, Asbridge, and Veugelers (2008) found that there is an association between diet quality and academic performance. The Diet Quality Index-International [DQI-I] ranks diet quality based on total daily consumption on a scale of 0-100 (a higher the score indicating a higher diet quality) and was used in the Florence et al. 2008 study as a basis to measure the diets of the students surveyed. According to Florence et al. (2008), this measurement is preferable over measurements of individual nutrients because people "do not consume single nutrients but combinations of foods" (p. 210). The DQI-I scale was deemed valuable in this study due to the fact that it takes into account adequacy, moderation, variety, and balance of individuals' diets and gives each factor an individual score (Florence et al., 2008). For the purpose of this review, it is important to understand the characteristics of eating habits graded by each component of the score, since this information is fundamental to correlating what type of nutritional habits had a bearing on academic performance. According to Florence et al. (2008), the dietary adequacy component ranks individuals' consumption of "foods and nutrients essential to a healthy diet such as fruits, vegetables, grains, dietary fiber, protein, iron, calcium, and vitamin C" (p. 211), while the dietary moderation component reflects individuals' intakes of saturated fat, salt and other empty calorie foods. The dietary variety component scores consumed food diversity, and the balance component ranks the ratios of carbohydrate, fat, and protein in the diet (Florence et al., 2008). It is interesting to note that "increased consumption of fruits and vegetables and moderate fat intake are considered as indicative of a high-quality diet" (Florence et al., 2008, p. 211). Approximately six months after students completed dietary surveys, the Elementary Literacy Assessment, which is a standardized test in Nova Scotia, was administered to the same students as a tool to measure academic performance as related to the students' dietary scores.

The results of this study demonstrated that there is indeed a connection between overall diet quality and academic performance. Of the 4589 students who submitted complete dietary information, the average DQI-I score was 62.4 with a range from 26.0 to 86.0 (Florence et al., 2008). After the literacy assessment was given, students with higher dietary scores were found to be less likely to fail any portion of the standardized assessment (Florence et al., 2008). According to the results, both the variety and adequacy components versus the moderation and balance components seemed to have more bearing on the literacy assessment scores (Florence et al., 2008). Also noteworthy was the fact that students with higher fruit and vegetable intakes, as well as lower fat intakes, were more likely to do well on the literacy assessment (Florence et al., 2008). According to Florence et al. (2008), their findings highlight "the value of consuming a diverse selection of foods in order to meet the recommended number of servings from each food group" (p. 213). Later in their summary, they also asserted that school programs should encourage the consumption of fruits and vegetables and discourage the over-indulgence in foods that are high in dietary fat in order to support improved assessment scores (Florence et al., 2008).

Although this study neither specifically looked at the impact of breakfast nor analyzed individual micro- and macronutrient consumption, the findings are still significant when applied to the functions of breakfast. By demonstrating that the overall diet quality of children *does* play a role in their academic successes, the research findings of Florence et al. (2008) also helps support the theory that the overall nutritional quality of breakfast is significant to students' cognitive abilities, since breakfast should be a daily indispensable source of caloric intake according to a study by

Matthys et al. (2007). The scope of the Florence et al. (2008) study is limited; however, its findings suggest the need for further research in this area.

Glycemic Index and Glycemic Load

Of similar nature the study of overall diet quality, research on the impact of the glycemic index [GI] and the glycemic load [GL] combination of breakfast foods on cognitive function stands out as a newly developing area of study. According to Giovannini et al. (2010, p. 98), mentioned earlier in this literature review, breakfast consumption positively effects cognitive functions including "problem solving, short-term memory, attention, and episodic memory in children" (Pollitt et al., 1983; Vaisman et al., 1996; Wesnes et al, 2003) most likely because of the ways that the brain metabolizes the glucose levels in various breakfast foods. In order to understand this correlation, both *glycemic index* and *glycemic load* need to first be defined.

According to KidsHealth, the glycemic index is a measure of how fast and how much the breakdown of foods, mainly carbohydrate foods, raises blood glucose levels (Glycemic index). This means that "foods with higher index values raise blood sugar more rapidly than foods with lower glycemic index values do" (KidsHealth, Glycemic index section, para. 2). The online dictionary definition also explained that glucose is the primary fuel for the body's cells and is acquired as the result of the absorption of the carbohydrate sugar (glucose) into the bloodstream (KidsHealth, Glycemic index). While glucose is clearly needed for energy, the rate of its absorption and level of its impact on the bloodstream are what is measured by the glycemic index.

Related to the glycemic index of foods, glycemic load refers to the amount of carbohydrates consumed in relation to those foods' GI (Higdon, 2005). According to Higdon (2005) with the Linus Pauling Institute Micronutrient Information Center:

> *The glycemic load of a food is calculated by multiplying the glycemic index by the amount of carbohydrate in grams provided by a food and dividing the total by 100. . . . The concept of glycemic load was developed by scientists to simultaneously describe the quality (glycemic index) and quantity of carbohydrate in a meal or diet. (Glycemic load section, para. 1)*

The glycemic load helps explain a food's potential to raise blood glucose levels and in what amounts of that certain food. It should be understood that both GI and GL mainly measure carbohydrate foods, as those are the foods that most often affect blood glucose levels.

In a study of sixty children aged 11-14 who were considered habitual breakfast eaters, Micha, Rogers, and Nelson (2010) found that the combination of GI and GL characteristics of breakfast affected cognitive function. According to Micha et al. (2010), their study was "the first of its kind to consider both GI and GL when assessing the effects of breakfast on CF [cognitive function] in teenage school children" (p. 955). The findings of this study may play an integral role in the future planning of breakfasts intended to maximize cognitive functioning abilities in school children, but the unchartered territory it covers will need to be further documented in other studies. For the purpose of this literature review, however, the findings will be explored for their potential future impact on breakfast consumption research and recommendations.

In the introduction of their report, Micha et al. (2010) cited the research of Kennedy and Scholey (2000) and Scholey and Kennedy (2004) on the link between glucose consumption and cognitive function, reporting that "the brain may be sensitive to short-term fluctuations of glucose supply, and . . . glucose content may induce the memory-enhancing effects of breakfast, by producing metabolic alterations" (p. 948). According to the hypothesis of Micha et al. (2010), the highest cognitive functioning levels would be produced by low-GI, high-GL breakfasts. Their reasoning was based on previous research of both GI and GL foods indicating that a low-GI meal would minimize blood glucose level fluctuations and a high-GL meal would increase the potency of the nutrients consumed (Micha et al., 2010, p. 949). According to Table 3 of their study, an example of a low-GI, high-GL breakfast would be Special K/Muesli/Fruit and Fiber cereals, semi-skimmed milk, orange juice, and sugar (Micha et al., 2010, p. 952). According to Table 2, this breakfast would have totaled approximately 500 calories, making it slightly higher in caloric count than several of the other breakfast meals (Micha et al., 2010, p. 951). After administering seven different cognitive function assessments, the results of their experiment demonstrated that over half of the assessments were associated with glycemic response (Micha et al., 2010, p. 953, see Table 5). More specifically, "the low-GI, high-GL breakfast was associated with better scores on the two CF tasks . . . that were reported by the participants to be the most difficult (that is, mentally demanding)" (Micha et al., 2010, p. 954). It is interesting to note that other studies referenced by Micha et al. (2010, p. 954) demonstrated a similar finding: namely, in order for the effect of GI and GL on cognition to be seen, the task must also be mentally demanding (Donohoe & Benton, 1999; Owens, Parker, & Benton, 1997; Scholey, Harper, & Kennedy, 2001; Sunram-Lea, Foster, Durlach, & Perez, 2001). In summation, this study showed that both GI and GL are important factors to take into consideration in regards to the correlation between breakfast consumption and cognitive function. Even more significant is the finding that low-GI, high GL breakfasts may be the one of the best characterizations of a healthy breakfast to support high academic performance in the classroom (Micha et al., 2010, p. 955).

Micro- and Macronutrients

Moving away from the studies of overall breakfast quality and glycemic impact, specific micro- and macronutrients have also been studied for their impacts on cognitive abilities. Of particular interest in this literature review are the studies demonstrating the influences of protein (including dairy foods) and iron on academic performance. Although grains, fruits, and vegetables have all been demonstrated to play a significant and beneficial role in overall nutrition and academic performance levels, the roles of the macronutrient protein and the micronutrient iron have been investigated and applied to students' breakfast habits to a lesser extent, specifically in school breakfast programs. The need for more research on the significance of dietary protein and iron intake should be based on the affects that these nutrients have on cognitive function. While most of the studies reviewed here do not directly mention breakfast, the principles can still be applied to the healthy habits that could be encouraged to maximize learning.

Proteins.

In the classifications of food groups, the USDA and DASH separate protein foods from dairy products and, in the case of DASH, from legumes, nuts, and seeds in regards to daily serving recommendations (CDC, 2010, What are the major food groups?); however, *protein*, as a

macronutrient, encompasses foods that contain high sources of the essential nutrient such as meat, seafood, dairy, and eggs, as well as some plant sources such as legumes, nuts, and seeds (WebMD, Protein directory). For the purpose of this review, all types of protein sources will be considered versus the stricter interpretations provided by the food group recommendations.

In a meta-analysis by Taras (2005) mentioned previously, various aspects of nutrition, including protein consumption, were reviewed for their impacts on student performance. In a study of 550 Chilean school children, Ivanovic et al. (1992) found that student academic performance was positively related to higher levels of protein intake, specifically those foods of the dairy variety. Taras (2005) noted that:

> *Achievement was significantly and positively correlated with frequency of consumption of dairy, meats, and eggs in both elementary and high schools. . . . Food habits explained 24% (elementary) and 17% (high school) of variance in academic achievement. Dairy products had greatest independent influence on achievement. p. 207*

In another study by Matthys et al. (2007) about the correlation between breakfast habits and adolescent overall nutrient profiles, the researchers found that both boys and girls who consumed high quality breakfasts had a significantly higher contribution of protein to other macronutrients proportionally in their meals. The reasons behind these findings were not explained by Taras (2005) or by Matthys et al. (2007), but might be understood more by the research of the following two studies that targeted the effect of protein malnutrition.

As a nutrient source, proteins have been found to positively impact tasks mainly directed by the brain's hippocampus, such as memory abilities, as well as the childhood development of higher cognitive processes (Kar, Rao, & Chandramouli, 2008; Lamport & Woodhouse, 2012; Valadares, Fukuda, Francolin-Silva, Hernandes, & Almeida, 2010). In a study by Valadares et al. (2010), protein malnutrition was studied in the cognitive and behavioral development of rats who were subjected to various cognitive tests to determine the effect that postnatal protein malnutrition would have on their cognitive abilities. The researchers found that the tasks most affected by protein malnutrition were those that were controlled primarily by the brain's hippocampus, which has been determined as very sensitive to protein inadequacy (Valadares et al., 2010). Valadares et al, (2010) identified protein as "one of the most important nutrients containing essential amino acids for the synthesis of structural proteins, enzymes, neuropeptides, and neurotransmitters" (p. 274), and the hippocampus as directly involved with spatial learning and memory, including the "correct processing of recognition memory" (p. 275). This being the case, the consumption of protein among school age children should be a concern where tasks require memory skills. In another small study of children in India, researchers attempted to determine the effect of chronic protein energy malnutrition [PEM] on the type and rate of cognitive impairment (Kar et al., 2008). Among their findings, they reported that "malnourished children showed poor performance on tests of higher cognitive functions like cognitive flexibility, attention, working memory, visual perception, verbal comprehension, and memory" (Kar et al., 2008, Discussion section, para. 2). Although the impact of this study on U.S. children is still unknown due to the unspecified level of PEM found among them, the importance of this study of Indian children was clearly identified, as PEM is known to be a

problem in India (Kar et al, 2008). More research is needed to establish the application of this study in U.S. settings. However, the crucial nature of dietary protein as needed for cognitive function grows more striking based on this evidence.

Iron.

Iron as a micronutrient is essential for proper cognitive function and is related to protein intake (Beard, 1995; Ohio State University [OSU] Extension, 2004; Taras, 2005). According to the OSU Extension (2004), iron is involved in many different functions of the body, including but not limited to carrying oxygen throughout the body, aiding in cognitive development, regulating temperature, metabolizing energy, and performing work. Good food sources of iron are defined as those that supply at least 10% of RDA in one serving size of that food (OSU Extension, 2004). Iron is divided into two types: heme and nonheme iron (OSU Extension, 2004). Heme iron primarily stems from animal sources (meat) and is more easily absorbed by the body than nonheme sources which stem from plant-based and fortified foods (OSU Extenstion, 2004).

As related to academic performance, iron-deficiency, which is also known as *anemia* at more serious levels of deficiency, negatively affects cognitive function (Beard, 1995; OSU Extension, 2004; Taras, 2005). According to Beard (1995), studies have shown that anemia causes "a negative effect on mental performance and psychomotor development in school-age, preadolescent, and adolescent individuals" (p. 709). Taras (2005) summarized the findings of his meta-analysis by noting that children with iron-deficiencies are academically disadvantaged without the supplementation of iron therapy. Specific studies worth referencing from the meta-analysis of Taras (2005) include both the findings of Halterman, Kaczorowski, Aligne, Auinger, and Szilagyi (2001) and of Otero, Aguirre, Porcayo, and Fernandez (1999). Halterman et al. (2001) found that the average standardized assessment math scores were lower among children with iron deficiency, and that children with iron deficiency were twice as likely to score below average in math. Otero et al. (1999) found that non-anemic, iron-deficient children had lower comprehension and verbal performance scores than those with normal iron levels, as well as levels of activity "suggesting developmental lag and/or a central nervous system dysfunction" (Taras, 2005, p. 204). These findings seem to suggest the significance of children's iron intake in relationship to students' chances of reaching their highest academic potential.

Conclusions

Based on the findings of the last several decades of research, the case for the consumption of a healthy breakfast grows stronger. What defines a healthy breakfast and, even, what are the best ways to support its consumption among school age children are questions that have not yet been answered to the satisfaction of the scholarly community. However, findings that have emerged as noteworthy include that (1) breakfast skippers are deficient in vital nutrients that are not often replenished throughout the rest of the day, (2) choosing to eat a high-quality breakfast is often a sign of similar healthy eating choices throughout the rest of the day, (3) breakfast consumption does affect academic performance, (4) even a questionably nutritious school breakfast seems to improve learning in the classroom, (5) the quality of the food consumed, specifically the adequacy of nutrients and the variety of foods, and the glycemic impact of the food consumed appear to have an impact on academic performance, and (6) a less-well explored topic of protein and iron

consumption may deserve a closer look in regards to the diets of U.S. school children and their cognitive abilities.

The health of U.S. school children is becoming a more grave concern, as data is released documenting their poor food choices (Van Horn, Banks, Vincent, & McCrindle, 2012). According to Van Horn et al. (2012), the consumption of salty, high-fat, prepared foods, prepackaged snacks, fruit juice, starchy and non-nutrient dense vegetables, and non-whole grains is on the rise among U.S. children, while the consumption of fruits, dark green and orange vegetables, legumes, and whole grains is not reaching adequate levels among this same population. More specifically, Van Horn et al. (2012) reported:

> *Intake of snack foods, desserts, and pizza – foods that are generally nutrient-poor and energy-dense – has increased from about 18% of kcal in the 1970s to 1980s to current intakes of about one-quarter to one-third of the total dietary intake of adolescents. Likewise, sugar-sweetened beverages constitute approximately half of all beverages consumed by children and . . . the intake of milk and pure fruit juice has gradually decreased over the last decade. (p. 67-68)*

If the data documenting the association between healthy food choices and cognitive abilities is to be believed, then there should be concern that the demonstrated poor food habits among U.S. adolescents may be a sign of correlating poor classroom performance. Yet, research seems to indicate that breakfast can "improve nutrient density" (Van Horn et al., 2012, p. 68) and, for a number of cognitive processes, provide "energy that is available both immediately and over the course of the morning" (Murphy, 2007, p. 31). A facet of the solution to poor academic performance may be at the fingertips of researchers, policymakers, educators, and parents: provide a large, healthy breakfast for children, and provide it often.

According to researchers, healthier students have a better chance to succeed academically (Basch, 2011; Florence et al., 2008; Kleinman et al., 2002), and breakfast eaters more often than not seem to be categorized as healthier students than those who skip breakfast (Giovannini et al., 2010; Murphy, 2007). Specifically among disadvantaged students, studies show that "educationally relevant health disparities" (Basch, 2011, p. 651) play a causal role in educational achievement gaps. According to Basch (2011), "No matter how well teachers are prepared to teach . . . educational progress will be profoundly limited if students are not *motivated and able to learn*" (p. 651). Basch (2011) associated health-related problems with students' struggle with motivation and academic performance. The solution that Basch encourages? A network of educator- and community-sponsored school health programs that are "high-quality, strategically planned, and effectively coordinated" (2011, p. 652). These school health programs would include services to improve malnourishment and the nutritional status of students (Basch, 2011). Also, the involvement of parents should not be underestimated where the health of students is concerned (Matthys et al., 2007; Ruglis & Freudenberg, 2010), but rather harnessed with accurate literature and training on the benefits and qualifications of a healthy breakfast. Overall breakfast quality *does* seem to make a difference in students' abilities to learn, and, as such, breakfast plays a vital role in the futures of students. All available resources from school breakfast programs to parental support should be utilized to best maximize academic achievement among all students. As Florence et al. (2008)

noted, “Academic performance influences future educational attainment and income, which, in turn, affect health and quality of life” (p. 213-214). More research on the precise qualifications of a high-quality breakfast is needed; however, the need for that high-quality breakfast does not seem to be in question if the promotion of high levels of cognitive function is desired.

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