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RESEARCH ARTICLE

The Link Between Nutrition and Physical Activity in Increasing Academic Achievement

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ABSTRACT

BACKGROUND: Research demonstrates a link between decreased cognitive function in overweight school-aged children and improved cognitive function among students with high fitness levels and children engaging in regular physical activity (PA). The purpose of this study was to examine whether regular PA and proper nutrition together had a significant effect on academic achievement.

METHODS: Using the seventh wave of the Early Childhood Longitudinal Study, Kindergarten Class 1998-99 (ECLS-K) dataset, linear regression analysis with a Jackknife resampling correction was conducted to analyze the relationship among nutrition, PA, and academic achievement, while controlling for socioeconomic status, age, and sex. A nonactive, unhealthy nutrition group and a physically active, healthy nutrition group were compared on standardized tests of academic achievement.

RESULTS: Findings indicated that PA levels and proper nutrition significantly predicted achievement scores. Thus, the active, healthy nutrition group scored higher on reading, math, and science standardized achievement tests scores.

CONCLUSIONS: There is a strong connection between healthy nutrition and adequate PA, and the average performance within the population. Thus, results from this study suggest a supporting relationship between students' health and academic achievement. Findings also provide implications for school and district policy changes.

Keywords: nutrition; physical activity; academic achievement; middle school; jackknife regression.

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School environments provide a unique atmosphere for children to not only learn, but to participate in physical activity (PA). Many studies have shown an association between school-based PA and academic performance among school-aged youth.[1-8] In addition to the positive implications of PA on one's health, several studies suggest PA may directly and indirectly impact academic achievement in physiological, cognitive, emotional, and learning mechanisms.[9,10]

The direct health benefits of PA include a decreased risk for hypertension, dyslipidemia, type 2 diabetes, metabolic syndrome, and some cancers; additional health benefits of PA include controlling body weight, improving mood and mental health as well as increasing muscle, and bone strength that prevents falls and improves ability to complete activities of daily living.[11,12] Regular PA is also associated with both a healthier and longer life.[13] Furthermore, a positive association has been established between PA and the reduction of obesity, insulin resistance, and metabolic risk in children and adolescents.[13] Of greater importance, however, is the association between obesity in young children and its continued prevalence in adulthood, as 70% of children that are obese as children will remain obese as adults.[14] Therefore, engaging children in PA at an early age is important to maintaining a child's overall health, as well as to instill foundational PA habits.

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Despite the known benefits of PA, nearly half of adolescents (ages 10 to 19) and young adults (ages 20 to 24), who make up 21% of the population of the United States,[15] are not vigorously active on a regular basis.[1] Along with the physiological health benefits of PA, increased PA has also been linked to psychological benefits.[16] Higher levels of self-esteem, and lower levels of anxiety and stress, which are directly connected to increased PA, have been associated with enhanced academic performance.[16] Moreover, several studies have linked a positive relationship between physical fitness and academic achievement, as well as other cognitive performance measures.[1,17-21] Specifically, Datar and Sturm found that if children, between the years of kindergarten and third grade, move from a healthy weight to being overweight, there was a significant association between weight increase and a reduction in test scores.[19] Gable et al found similar results concluding an association of obesity with lower first- and second-grade test scores.[20]

To assess the association of physical fitness and academic achievement, the California Department of Education (CDE) examined reading and mathematics scores from the Stanford Achievement Test and individually matched these scores with fitness scores of 353,000 fifth graders, 322,000 seventh graders, and 279,000 ninth graders.[22] A positive relationship was found between physical fitness and the Stanford Achievement Test across all 3 grade levels. The study also noted that as levels of fitness increased, scores of academic achievement increased.

Coe et al substantiated the findings of the CDE study, as their study found a positive relationship between vigorous PA and higher grades in a school setting.[23] Another study conducted by Castelli et al found that physical fitness was related to academic performance in third and fifth grade children.[1] This study also provided supporting evidence to the findings of the large scale CDE study and supports the notion that physical fitness is related to academic achievement, particularly standardized academic achievement tests.[1] Castelli et al also found higher reading and mathematics standardized test scores were positively associated with aerobic fitness.[1]

Along with academic achievement, academic behavior is also important to a child's success in the classroom. Academic behaviors, as defined by a systematic review by Sullivan et al, encompasses a range of behaviors that may have an impact on a student's academic performance including on-task behavior, organization, planning, attendance, scheduling, and impulse control.[24] Teacher ratings of academic behaviors such as attention, internalizing behavior, and externalizing problems at age 6 were linked to the prediction of math and reading achievement at age 17.[24] Sullivan et al also found a positive relationship between PA and the academic behaviors of better attention and on-task behaviors in the classroom.[24] A correlational study found by the Sullivan et al systematic review found an association between 8- and 9-year-old children who have one or more daily recess periods of more than 15 minutes and better teacher ratings of academic behaviors.[24] This study further highlights the far reaching benefits of PA and the importance of PA for school-aged children.

PA also has a significant effect on brain function. Hillman et al found that physical fitness level increases electromagnetic activity in the brain during cognitive testing.[25] This research mirrors findings that found a strong link between overweight school children and lower cognitive functioning.[26] In addition, recent interventions targeting increased PA levels in obese children showed improvements in academic achievement within that population.[26,27] Physical fitness, a measure of PA, is also related to academic achievement, particularly standardized academic achievement tests.[28] Crosnoe and Muller found a negative correlation between academic achievement and overweight high school students at risk for obesity;[28] further substantiating the vital role that PA and physical fitness play in academic achievement.

A healthy diet is one which consists of the daily consumption of a variety of foods consisting of plant based (including fruits and vegetables), grains, proteins, dairy, and oils.[29,30] In addition, consuming a healthy diet includes (1) choosing foods and beverages in amounts that help achieve and maintain a healthy weight, (2) eating 5 or more servings of a variety of vegetables and fruits each day, (3) choosing whole grains in preference to processed (refined) grain, and (4) limiting consumption of processed meats, as well as red meats.[30]

Extensive research in human nutrition has established a relationship between adequate intakes of fruits and vegetables and the prevention of several diseases.[31-36] Consuming 5 or more servings of fruits and vegetables each day has been linked to disease fighting benefits including the prevention of some cancers, hypertension, dyslipidemia, and coronary heart disease; fruit and vegetable intakes have also been shown to aid in weight management.[36]

A healthy diet is particularly important for children, as they require the optimal nutrient intake to meet the basic demands of growth and development. About 56 million American children are enrolled in public schools where they spend approximately one-half of their waking hours.[37] Furthermore, 31 million participate in the National School Lunch Program[37] indicating that a focus on nutrition within schools would be an effective way to use scarce resources and help develop healthy youths.

Proper nutrition also plays a role in mental function and academic achievement.[21] Findings from the Li et al

study found a relationship between overweight youth and decreased mental function.[26] Ickovics et al found a link between nutrition, PA and higher academic performance.[37] In addition, Ickovics et al determined a decrease in cognitive functioning was associated with being overweight and having hypertension.[37]

Studies have determined that regular PA as well as proper nutrition can increase cognitive function;[21] however, the effects of PA and nutrition on academic achievement have not been extensively examined together. Moreover, there is a paucity of research that assesses the interplay of nutrition and PA on academic achievement. This study aimed to examine the interactions of academic achievement, regular PA, and proper nutrition. The purpose of this study is to address this gap in the literature by examining the influence of PA together with nutrition habits on academic achievement in a large, nationally representative kindergarten through eighth grade data set (ECLS K-8).

METHODS

Instrumentation

The Early Childhood Longitudinal Study (ECLSK-8) data set was used for this study. The ECLS K-8 data set is a longitudinal, nationally represented data set with seven waves of data. Data were gathered beginning in 1998-1999. Two waves of data were gathered during the kindergarten year, during the fall and spring. Waves 3 and 4 were conducted during the fall and spring of the first grade. Wave 5 was not conducted until the sample was in the third grade, wave 6 followed during the fifth grade and the final wave of data was gathered during the samples eighth grade year in 2007.

Participants

Children from public and private schools attending both full and part day kindergarten were included. A total of 21,260 students participated in the initial wave. The sample represents diverse backgrounds including socioeconomic and racial/ethnic diversity. For the purposes of this study, data from the final wave, the eighth grade year, were analyzed for a total sample size 9720.

Ethics Regarding Data Collection

Data used for the purposes of this study were obtained from the ECLSK-8 public-use files in which several modifications were made to the data to reduce the likelihood that any respondent could be identified in the data. Unusual or rare responses were top- or bottom-coded on the public-use files. For example, the number of kindergarten teachers who did not have at least a bachelor's degree was so small that such teachers are grouped in the same category as teachers who have a bachelor's degree. Bottom and top coding prevented the identification of schools, teachers, parents, or children who had unique characteristics without affecting overall data quality. Outlier data appear in their original form on the restricted files.

Certain variables with too few cases having valid data or a sparse distribution were suppressed in the public-use files. For example, no data are reported for those variables.

Certain continuous variables were transformed into categorical variables, and certain categorical variables had categories collapsed in the public-use file. This categorization and collapsing reduced disclosure risk, while still providing data with adequate variability that did not interfere with statistical analyses used for this study.

The collection of data from children was gathered by trained assessors who visited the children in their schools. The direct child assessment, which was untimed and conducted one-on-one with each child, collected information about children's reading and mathematics skills and knowledge in each round of data collection, their general knowledge in subjects such as science and social studies in kindergarten and first grade, and their science knowledge in third, fifth, and eighth grades. In addition, the assessment included measurements of height and weight. In the third, fifth, and eighth grades, children completed questionnaires on various topics including their perceptions of their social and academic competence and skills, their school experiences and activities, and their diet.

The ECLS-K dataset is built upon a conceptual foundation that emphasizes the important interactions among the child, family, school, and community. It also recognizes the importance of an individual's health status, socioemotional and intellectual development, and includes these factors within the conceptual framework used to develop the ECLS-K dataset.

Procedure

Data during the first 4 waves of data collection were provided by parents, teachers and school administrators. In addition to parents, teachers and school administrators, students were asked to fill questionnaires beginning in third grade during wave 5. Sampling procedures included a multistage probability design to select a nationally representative sample of kindergarten students. Stages included sampling first based upon geographic area, second by school and third by student demographics. The initial sample was refreshed with additional first grade students during the third wave of data collection, therefore the sample is considered a national representative sample of kindergarten and first grade students. However, because additional students were not added for the

remaining waves of data, the sample should not be considered a representative sample of third, fifth, or eighth grade students. This is due to the exclusion of certain subgroups of students, including students who enrolled in kindergarten before the fall of 1998 and were retained in 1 or more grades, immigrant children who entered school after the first grade and home school children who entered school after first grade. Data collection included computer-assisted interviews, computer-assisted phone interviews, mail questionnaires, self-administered questionnaires and on-site questionnaires. Data were collected from students, parents/guardians, teachers, and schools.

Scales

Nutrition. A single scale of nutrition was developed using 8 items. Four of the items were considered indicators of ''healthy nutritional'' practices; consumption of salad, carrots, other vegetables, and fruits. Four items were considered indicators of ''unhealthy nutritional'' practices; consumption of fast food, sweets, salty snacks, and sugary drinks. All items were asked over the last week. To compare nutrition with PA level within the analysis, nutrition items were transformed from weekly to monthly in order to match the time scale of the PA items. Items were transformed using the following parameters to create a frequency scale with equal distance between responses; did not eat = 0, 1 to 3 times a week = 2, 4 to 6 times a week = 5, 1 time a day = 7, 2 times a day = 14, 3 times a day = 21, and 4 or more times a day = 28. To form the 2 nutrition groups, the scales were created using the sum of all items and the scales were used to compute quartiles where 0 = none. Respondents were included in the unhealthy nutrition group if they had indicated they did not eat any of the items in the healthy nutrition scale and were in the top 2 quartiles of frequency of eating unhealthy nutrition foods. Respondents were included in the healthy nutrition scale if they had indicated that they did not eat any of the items in the unhealthy nutrition scale and were in the top 2 quartiles of frequency for eating healthy nutrition foods.

Physical activity. Two scales were also created to measure activity levels. Three items were used to create a non-activity scale, based upon the sum. The items included (1) number of hours watching TV, (2) playing video games, and (3) using the internet. Three items were also used to create, based upon the sum, an activity scale. These items included (1) number of hours playing sports outside of school, (2) number of hours exercising, and (3) number of hours in Physical Education (PE) class. All 6 items were asked for the weekdays and excluded activities on the weekends. Respondents were separated into quartiles for both scales. The active group consisted of all the respondents who were in the top quartile for hours of other sports and exercise and the top 2 quartiles for PE and in the lowest quartile for TV viewing, video game playing, and internet use. The non-active group consisted of all the respondents who were in the top 2 quartiles for TV viewing, video game playing, and internet use and the lowest quartile for hours of other sports, exercise, and PE.

Data Analysis

Jackknife liner regression analysis was used to determine the effects of nutrition and PA on eighth grade reading, math, and science achievement scores. The jackknife, a sample reuse statistical methodology, is used to enlarge the sample data and re-estimate the model in order to generate parameter estimates that approximate the true population parameter.[38] Thus, the goal of the jackknife is to estimate a parameter of a population of interest from a random sample of data from this population. For example, Jackknife resampling uses the provided full data set, or a given data generating mechanism (eg, coin toss) that is a model of the process of interest to produce a new sample of simulated data, and examines the results of those samples.[39] Also, the jackknife resampling method reduces sample bias and is an interval estimator.[38] Given that data from the ECLSK-8 data set was used from the final wave of data collection for this study, the use of jackknife as a sample reuse methodology for the eighth grade sample allows for an approximation of the true population parameters.

The outcomes for the study included the Item Response Theory (IRT)[40,41] scale scores for reading, science, and math during the eighth grade. The predictor variables included the nutrition and PA scales. Covariates included socioeconomic status (SES), age, and sex, all self-reported measures. The SES scale includes household-level data on father and mother's education level, father and mother's occupation, and household income.

A series of linear regression analyses were used to examine the difference between reading, science, and math IRT scores among the groups. All tests controlled for SES, age, and sex. A final group of linear regression tests were conducted to test the moderation of nutrition and PA on the 3 scales of academic achievement by including the interaction term between nutrition and activity.

RESULTS

A linear regression analysis with a Jackknife resampling correction was used to examine whether PA and/or nutrition significantly predicted reading, math and science achievement scores while controlling for SES, age, and sex. This method of resampling was utilized to reduce the potential for biased estimation

Table 1. **Means and Standard Deviations for All Groups***

	Reading		Math		Science	
	M	SD	M	SD	M	SD
Healthy nutrition	177.21	25.63	146.43	20.50	88.46	13.16
Unhealthy nutrition	144.12	29.54	120.25	25.07	68.09	18.50
Active	169.35	26.06	143.39	20.47	85.39	14.62
Non-active	160.93	30.06	128.31	23.47	76.10	17.37
Healthy nutrition, active	173.69	23.82	143.05	16.09	88.45	10.87
Unhealthy nutrition, non-active	139.48	34.21	111.56	28.36	61.98	19.49

*N = 9720.

of results and to obtain better estimates.[42] The means and standard deviations for all groups are shown in Table 1.

Reading

The results of the Jackknife regression analysis for reading indicated that PA, nutrition, the interaction of PA and nutrition were significant predictors of reading scores, while controlling for SES, age, and sex ($F(6, 84) = 222.74$, $p < .01$; Table 2), and 28.82% of the variance in reading scores can be explained by the model ($R^2 = 0.29$). When examining variables within the model, nutrition, the interaction of nutrition and PA, SES and sex were significant predictors of reading scores (Nutrition [N], $t = 9.16$, $p < .01$; Nutrition × Activity [N × PA], $t = -2.88$, $p < .01$; SES, $t = 27.74$, $p < .01$; Sex [S], $t = 1.43$, $p < .01$). In addition, the prediction equation for reading scores ($Y_{reading} = 104.708 + 0.202\,N + 0.086PA - 0.0285$ [N × PA] + 10.303SES + 0.116Age − 5.939S) indicates the following for the significant predictors: (1) as nutrition behavior increased by 1 unit, reading scores increased by.20, (2) as the interaction term for nutrition and PA increased by 1 unit, reading scores decreased by .03, (3) as SES increased by 1 unit, reading scores increased by 10.30, and (4) sex influenced reading scores with girls scoring higher by almost 6 points (5.94).

Math

Results for math indicated that nutrition, PA, and the interaction of PA and nutrition were significant predictors of math scores, while controlling for SES, age, and sex ($F(6, 84) = 210.59$, $p < .01$; Table 3), and 25.23% of the variance in math scores can be explained by the model ($R^2 = 0.25$). When examining variables within the model, nutrition, PA, the interaction of nutrition and PA, and SES all significantly predicted math scores (Nutrition [N], $t = 10.30$, $p < .01$; Activity [PA], $t = 4.26$, $p < .01$, Nutrition × Activity [N × PA], $t = -4.50$, $p = 0.000$; SES, $t = 25.31$, $p < .01$). In addition, the prediction equation for math scores ($Y_{math} = 111.2186 + 0.177\,N + 0.850PA - 0.0380$ [N × PA] + 7.419SES + 0.0290A − 0.931S) indicates the following for the significant predictors: as healthy nutrition behavior increased by 1 unit, math scores increased by 0.18, and as PA levels increased by 1 unit, math scores increased by 0.85. As the interaction terms for nutrition and PA increased by 1 unit, math scores decreased by 0.38 and as SES increased by 1 unit, math scores increased by 7.42.

Table 2. **Linear Regression Reading Item Response Theory Scores†**

	B	Jackknife SE	t	95% CI
Nutrition	0.20	0.02	9.16***	0.16-0.25
Activity	0.86	0.23	0.38	−0.37-0.54
Nutrition × Activity	−0.03	0.01	−2.88**	−0.05-(−0.01)
SES‡	10.30	0.37	27.74***	9.56-11.04
Age‡	0.11	0.08	1.43	−0.05-0.28
Sex‡	5.94	0.94	6.33***	4.08-7.80

*p < .05, **p < .01, ***p < .000.
B, Betas or coefficients; SE, standard error; t, t statistic; CI, confidence interval.
Adjusted $R^2 = 0.29$.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99. Restricted-Use Data File and Electronic Codebook.
†N = 9720.
‡Covariates.

Table 3. **Linear Regression Math Item Response Theory Scores†**

	B	Jackknife SE	t	95% CI
Nutrition	0.18	0.02	10.30***	0.14-0.21
Activity	0.85	0.20	4.26***	0.45-1.25
Nutrition × Activity	−0.04	0.01	−4.50***	−0.05-(−0.02)
SES‡	7.42	0.29	25.31***	6.84-8.00
Age‡	0.03	0.08	0.37	−0.13-0.19
Sex‡	−0.93	0.72	−1.30	−2.36-0.50

*p < .05, **p < .01, ***p < .000.
B, betas or coefficients; SE, standard error; t, t statistic; CI, confidence interval.
Adjusted $R^2 = 0.29$.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99. Restricted-Use Data File and Electronic Codebook.
†N = 9720.
‡Covariates.

Science

Science score results indicate that 28.25% of the variance in science scores can be explained by the predictors of the model ($R^2 = 0.2825$) and PA, nutrition, and the interaction of nutrition and PA were significant predictors of science scores, while controlling for SES, age, and sex ($F(6, 84) = 215.63$, $p < .01$; Table 4). When examining variables within the model, nutrition, the interaction of nutrition and PA, SES and sex all significantly predicted science scores (Nutrition, $t = 10.71$, $p < .01$; Nutrition × Activity, $t = -4.25$, $p < .01$; SES, $t = 28.33$, $p < .01$; sex, $t = -4.36$, $p < .01$). In addition, the prediction equation for science scores ($Y_{science} = 50.05549 + 0.143\,N + 0.171PA - 0.025$ [N × PA] + 5.830SES + 0.098A − 2.371S) indicates

Table 4. **Linear Regression Science Item Response Theory Scores**[†]

	Coef.	Jackknife SE	t	95% CI
Nutrition	0.14	0.01	10.71***	0.12-0.17
Activity	0.17	0.16	1.04	−0.16-0.50
Nutrition × Activity	−0.03	0.01	−4.25***	− 0.04-(−0.01)
SES[‡]	5.83	0.21	28.33***	5.42-6.24
Age[‡]	0.10	0.05	1.82	−0.01-0.21
Sex[‡]	−2.37	0.54	−4.36***	− 3.45-(−1.29)

*p < .05, **p < .01, ***p < .000.
B, betas or coefficients; SE, standard error; t, t statistic; CI, confidence interval.
Adjusted $R^2 = 0.29$.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99. Restricted-Use Data File and Electronic Codebook.
[†]N = 9720.
[‡]Covariates.

the following: (1) as healthy nutrition behavior increased by 1 unit, science scores increased by 0.18, and (2) as the interaction term of nutrition and PA increased by 1 unit, science scores decreased by .38. Furthermore, as SES increased by 1 unit, science scores increased by 7.42, and sex influenced science scores with males scoring higher by 2.37 points.

DISCUSSION

The aims of our study were to determine if regular PA and proper nutrition together had a significant effect on academic achievement. It has been well established that regular PA has a significant effect on brain function. A relationship between overweight youth and decreased mental function has also been established.[26] However, few studies examine the interactions of academic achievement, regular PA, and proper nutrition.

Our findings suggest that regular PA in combination with proper nutrition may influence academic achievement scores. More specifically, data analysis results showed that a non-active, unhealthy nutrition group scored lower on reading, math, and science standardized test scores when compared with an active, healthy nutrition group, while controlling for SES, age, and sex.

Limitations and Further Studies

Although there were many strengths of this study, there were also some limitations. The nutrition scale dichotomized nutrition whereas the reality is likely to be a combination of eating both healthy and unhealthy nutritional foods on a continuum. The nutrition scale included 4 items that were considered indicators of ''healthy nutritional'' practices: consumption of salad, carrots, other vegetables, and fruits; while ''unhealthy nutritional'' practices were indicated by 4 items including the consumption of fast food, sweets, salty snacks, and sugary drinks. Although the categorization of healthy foods and unhealthy foods are consistent with the literature,[29,30] the detrimental effects of unhealthy nutritional practices may far outweigh the benefits of healthy nutritional practices. For example, children who drink sugary drinks (1 item of the unhealthy nutritional practices scale) on a daily basis have a 60% risk for becoming overweight or obese than children who do not consume sugary drinks on a daily basis.[43] The degree to which unhealthy nutritional habits negatively affected academic achievement cannot be clearly delineated when compared to the positive effects of a healthy diet on academic achievement. Therefore, a more nuanced measure of nutrition is recommended for future studies. In addition, not all physical activities in the study were equal. It is recommended that future studies look at differences in types of PA to get a clear measure of the different types of PA. Also, the study controlled for SES and sex; however, other factors may influence the relationship between nutrition and PA.

Also, the transformation of the nutrition scale variable from weekly to monthly in order to match the time scale of the PA items may have caused this variable to be more heavily weighted when combined with the PA variable; thus, yielding negative coefficients for the interaction term of nutrition and PA in all achievement results ($Y_{reading} = -0.0285$ [N × PA]; $Y_{math} = -0.0380$ [N × PA]; $Y_{science} = -0.025$ [N × PA]). Nutrition items were transformed using the following parameters to create a frequency scale with equal distance between responses; did not eat = 0, 1 to 3 times a week = 2, 4 to 6 times a week = 5, 1 time a day = 7, 2 times a day = 14, 3 times a day = 21, and 4 or more times a day = 28. However, in the attempt to create a scale equidistant between responses, this may have altered the weight of this variable with each permutation in the jackknife regression calculation. For example, for the reading achievement scores model, nutrition increases reading by 0.20 on average, and activity increases reading by 0.09 on average. It might be assumed that the combination of nutrition and activity would increase reading by 0.29; however, the results from the model found that as the interaction of nutrition and PA increased by 1 unit, reading scores decreased by 0.03. The decrease in reading scores by 0.03 could be attributed to the weighted effect of nutrition, as the transformation of the nutrition variable may have caused it to be weighted more heavily than PA. The negative interaction term coefficient may also indicate a point of diminishing return that when combining both nutrition and PA; whereas no additional increase in reading scores can be found with the combination of proper nutrition and adequate PA.

This study was delimited to eighth graders. It is also recommended that further studies examine other populations including high school and elementary

school, as these populations also benefit from proper nutrition and involvement in PA. In 2006, only 3.8% of elementary schools (excluding kindergarten), 7.9% of middle schools, and 2.1% high schools provide daily PE or its equivalent for the entire school year for students in all grades in the school.[44] Sadly, 22% of schools do not require students to take any form PE.[44] Therefore, studies targeting these populations could help establish a case for increasing PE and nutrition education efforts in schools; considering the many benefits of proper nutrition and regular PA including effects the positive effects these variables have on academic achievement.

Conclusion

Results from this study suggest a supporting relationship between students' health and academic achievement. The non-active, unhealthy nutrition group scored lower on reading, math and science standardized test scores when compared with an active, healthy nutrition group.

IMPLICATIONS FOR SCHOOL HEALTH

Academic achievement encompasses the grades and test scores a student receives which are a reflection of a student's education.[24] The results from this study suggest a supporting relationship between students' health and academic achievement. Student's health is of grave concern, as nearly 17% of children and adolescents are obese (affecting about 12.7 million children and adolescents).[45] With children spending up to 30 hours each week at school, the school setting is the perfect environment for children to engage in regular PA and for nutrient rich school lunches and/or meals to be a focus.[24,46] Schools can use the findings of this study as a means to do the following:

- Address and implement district policies focusing on improving nutrition opportunities within the school day
  - Higher nutritional school breakfasts and lunches
  - Healthier vending machine snacks options
- Increase opportunities for physical activities and/or incorporating various types of PA into a classroom lesson. This is of importance because physical education (PE) programs have been reduced in schools, often to implement other academic programs in its place;[24] contrary to the findings of this study.
  - For example, having a lesson such as *Spelling Freeze Tag* where, in an outdoor environment, students run within an area marked off by cones.[47] When students tag each other, the tagged student ''freezes'' in place with hands raised.[47] Another student with a list of spelling words quizzes the ''frozen'' student.[47] The student is released if the answer is correct and is allowed to continue running while trying to avoid being tagged.[47] If not correct, a second word is presented to the student.[47]

It is important for schools to focus efforts on improving nutrition opportunities within the school day for children, as proper nutrition has a significant influence on increasing academic achievement. Also, including novel approaches to PA and continuing PE classes will have tremendous implications for a child's health, as well as child's ability to succeed academically.

Human Subjects Approval Statement

Secondary data analyses were conducted by the researchers using data from the seventh wave of the Early Childhood Longitudinal Study, Kindergarten Class 1998-99 (ECLS-K). The ECLS K-8 dataset are public-use files in which several modifications were made to the data in order to reduce the likelihood that any respondent could be identified in the data. Unusual or rare responses were top- or bottom-coded on these public-use files.

Because the data were de-identified, a full review by the University of Missouri Institutional Review Board (IRB) was not necessary. However, the researchers did confirm with the University of Missouri's IRB that all data contained in the dataset was indeed anonymous and were given permission to move forward with the study. In addition, the data are freely available on the Early Childhood Longitudinal Program (ECLS) site (https://nces.ed.gov/ecls/) which implies that all public use data may be used for further analyses by researchers.

The researchers gained additional consent and ensured proper ethics were followed for the study by contacting the National Center for Education Statistics (NCES) located in Washington, DC via e-mail. Correspondence took place between the researchers and the appropriate staff member at NCES that was assigned to all inquiries regarding the elementary secondary dataset. Even though the dataset is intended for public use, additional permission was granted by NCES. Therefore, through these various measures, the researchers are confident that the ethics and consent of participants were fully upheld.

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