

Examining the Impact of Integrating Physical Activity on Fluid Intelligence and Academic Performance in an Elementary School Setting: A Preliminary Investigation

Julian A. Reed, Gilles Einstein, Erin Hahn, Steven P. Hooker,
Virginia P. Gross, and Jen Kravitz

Purpose: To examine the impact of integrating physical activity with elementary curricula on fluid intelligence and academic achievement. **Methods:** A random sample of 3rd grade teachers integrated physical activity into their core curricula approximately 30 minutes a day, 3 days a week from January 2008 to April 2008. Noninvasive fluid intelligence cognitive measures were used along with State-mandated academic achievement tests. **Results:** Experimental Group children averaged close to 1200 pedometer steps per integration day, thus averaging 3600 steps per week. Children in the Experimental Group performed significantly better on the SPM Fluid Intelligence Test. Children in the Experimental Group also performed significantly better on the Social Studies State mandated academic achievement test. Experimental Group children also received higher scores on the English/Language Arts, Math and Science achievements tests, but were not statistically significant compared with Control Group children. Children classified in Fitnessgram's Healthy Fitness Zone for BMI earned lower scores on many of the SPM Fluid Intelligence components. **Discussion:** This investigation provides evidence that movement can influence fluid intelligence and should be considered to promote cognitive development of elementary-age children. Equally compelling were the differences in SPM Fluid Intelligence Test scores for children who were distinguished by Fitnessgram's BMI cut points.

Keywords: physical activity, physical education, health promotion

Participating in regular physical activity is a necessary preventive behavior for youth to reduce the risks of developing chronic diseases while increasing the quality and perhaps the longevity of one's life. Recent data presented by the Centers for Disease Control and Prevention (CDC)¹ has revealed that the prevalence of overweight youth is increasing: for children age 2 to 5, prevalence increased from 5.0% in 1980 to 13.9% in 2004; for those age 6 to 11, prevalence increased from 6.5% to 18.8%; and for those age 12 to 19, prevalence increased from 5.0% to 17.4% during the same time span, respectively. Furthermore, overweight children and adolescents are more likely to have risk factors associated with cardiovascular disease (such as high blood pressure, high cholesterol, and Type 2 diabetes) than are other children and adolescents and are more likely to become obese adults. According to the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), more than 80% of individuals with Type 2 diabetes are overweight.²

Reed is with the Dept of Health and Exercise Science, Furman University, Greenville, SC. Einstein and Hahn are with the Dept of Psychology, Furman University, Greenville, SC. Hooker is with the Prevention Research Center, University of South Carolina, Columbia, SC. Gross and Kravitz are Furman Advantage Fellows, Furman University, Greenville, SC.

In addition, the CDC estimates that 48.3 million Americans will have diabetes by the year 2050.³ One study revealed that approximately 80% of children who were overweight at ages 10 to 15 were obese adults at age 25 years old.⁴ Another study found that 25% of obese adults were overweight as children.⁵ The latter study also found that if overweight begins before the age of 8, obesity in adulthood is likely to be more severe. More than 65% of American adults are obese or overweight according to the CDC's recent calculations.¹ Despite the proven benefits of physical activity, more than one-third of young people in grades 9 to 12 do not regularly engage in vigorous physical activity. Available data suggest the prevalence of obesity is more related to a lack of physical activity than increased food intake alone.⁶ Regrettably, youth spend more of their leisure time playing video-games, watching television and engaging in sedentary activities which are linked to the current childhood obesity epidemic. Childhood obesity is one of the most dangerous health threats facing youth, considering that approximately 25 million kids are overweight or obese.⁶

Numerous studies have examined the impact of physical activity on brain plasticity resulting in the identification of a variety of therapeutic enhancements. Movement has been documented to increase brain-derived neurotrophic factor (BDNF) which enhances learning

and cognition which, ironically BDNF is regulated by physical activity.⁷⁻⁹ Furthermore, regular physical activity has been found to promote structural changes in the hippocampus region of the brain, which is an important area for memory.⁷ Regular physical activity has also been found to increase neurons, dendrites and synapses-essential structural elements located throughout the central and peripheral nervous systems.⁷⁻⁹

More than 3 decades ago, Gabbard and Barton¹⁰ found a positive correlation between physical activity and school performance; yet elementary school children remain sedentary throughout the school day.¹¹ A recent review paper by Sibley and Etnier¹² on this topic found that exercise training is significantly linked to improved cognition in youth. Being an overweight child has also been reported to be associated with poor IQ test performance.^{13,14} Judge and Jahns¹⁵ recently examined the associations between overweight children and academic performance from recent data collected in the Early Childhood Longitudinal Study and these data reveal that overweight 3rd grade children had significantly lower math and reading tests scores in comparison with non-overweight children in the same grade. A program entitled Collaborating with Classroom Teachers to Increase Daily Physical Activity: The Gear Program discovered that integrating physical activity into the classroom can invigorate students, as well as providing positive effects on student learning.¹⁶ In addition, Blakemore¹⁷ reported that the brain is activated during physical activity by increasing blood flow to essential areas that stimulate learning. Strong associations between the cerebellum and memory, spatial perception, language attention, emotion, nonverbal cues and the decision making ability of students have also been found.^{9,17}

An established relationship between physical activity and the cognitive abilities of the cerebellum has also been identified. Research also suggests that the increased blood flow as a result of movement enhances the cerebellum by promoting specific cognitive functions.^{9,17,18} Carlson and colleagues¹⁹ recently investigated the link between time spent in physical education and academic achievement from data collected on children from kindergarten through 5th grade and discovered a significant increase in academic achievement in math and reading among girls enrolled in higher amounts of weekly physical education. Researchers at the RAND Institute identified that overweight kindergartners had significantly lower math and reading test scores in comparison with children who were not overweight.²⁰ Kolb and Whinshaw²¹ a decade ago, discussed how the pattern of neural specialization often referred to as the pruning of synapses in the nervous system can be determined in part, by environmental stimulation. Moreover, Hillman and colleagues²² examined EEG brain activity in children who were considered to have a high level and low level of fitness while performing a choice-reaction test. Children who were considered to possess a high level of fitness in their study performed this task more rapidly and had larger P3 amplitudes that are consistent with enhanced executive functioning.

Unfortunately, the levels of overweight youth continue to increase at a striking pace. Studies document that students in the US are significantly less active in comparison with their Australian and Swedish peers²³ and have significantly higher BMI values. Physical activity, like many behaviors, is complex and influenced by a number of variables. To change an individual's activity patterns, the behavior must be modified. With a significant percentage of American children inactive the probability of them continuing this trend into adulthood is significant.^{5,11}

The purpose of the current study was to examine the impact of integrating physical activity with elementary curricula on fluid intelligence and academic performance in an elementary school setting. Fluid Intelligence measures the ability to reason quickly and abstractly. It is thought to be a critically important component of intelligence, and it assesses one's ability to solve problems in situations that are not heavily dependent on previously learned knowledge. A secondary purpose of the current study was to examine if fluid intelligence and academic achievement scores varied by BMI values of 3rd grade elementary students.

Methods

Sample

A random sample of ($n = 155$) 3rd grade students from ($n = 6$) classrooms participated in the current study. Three classrooms comprised of ($n = 80$) students were randomly assigned to the Experimental Group. Three classrooms comprised of ($n = 75$) students were randomly assigned to serve as Controls. The Experimental Group in the current study integrated physical activity (ie, fundamental skills: running, hopping, walking) into their core curricula (ie, Language Arts, Math, and Social Studies) approximately 30 minutes a day, 3 days a week beginning January 22, 2008, and ending April 25, 2008. All experimental group children performed each of the physical activities during the integrative lessons. Random audits by direct observation were used to monitor fidelity of intervention delivery. All physical activities in the current study were performed in the classroom with no equipment. The movement forms (ie, fundamental skills) described previously is consistent with the current types of physical activities performed regularly in elementary school settings.²⁴

Procedures

Personal information collected from the current study was unidentifiable per the use of systematic coding and was only available to the research team. This process served to limit contamination by both Experimental and Control classroom teachers. Permission was sought and received from the school's principal before gathering data. Human Subject's Review Committee protocol requirements were met at the university and school district level before data collection. Student identification numbers were used to maintain subject confidentiality.

Physical Activity Measures

Physical activity in the Experimental Group was measured with a NEW LIFESTYLES DIGI-WALKER pedometer²⁵ model number SW-200. The pedometer was worn on the hip and measured vertical acceleration, recording a step each time the hip moved up and down. Pedometers have a suspended arm mechanism inside the counter (similar to a clock pendulum), which detects steps and other movements. The DIGI-WALKER pedometer, manufactured by Yamax Inc., Tokyo, Japan, was chosen for its accuracy and reliability in calculating daily steps taken. The Yamax brand step counter, DW-model (predecessor to the SW-model), measured number of steps and distance covered within 1% accuracy rate for adults on a sidewalk course.²⁶ Researchers²⁷ found a high correlation ($r = .95$) between pedometer readings and behavioral observation of physical activity with children age 9 to 11. Kilanowski et al²⁷ confirmed pedometers were a valid method of measuring large samples and a good source of feedback for intervention studies. In addition, the unobtrusive size and economical cost makes the pedometer a useful objective measure of children's physical activity. Children assigned to the Experimental Group were properly trained to wear the pedometer. The pedometer was reset to zero before beginning the integration activity and the steps were recorded by each Experimental Group teacher immediately following the lesson and compiled in a notebook for the researchers. The pedometer remained closed during the movement activity. Although the pedometer selected was a valid and reliable method to measure physical activity in the current study, activity intensity, duration and frequency were not allowable outcome measures with this particular device and, therefore, were not collected.

Previous Day Physical Activity Recall (PDPAR)

The PDPAR was used to assess the perceptions of physical activity of the children in both the Experimental and Control Groups in the current study. The PDPAR was administered during the first and last week of the current study resulting in 2 administrations. The rationale for administering the PDPAR was to identify physical activity differences of children in both groups that could have influenced the results. The purpose of the PDPAR is to evaluate physical activity from the previous day after school. MET values are assigned to all of the activities and summed to compute 1 score for each child. The Compendium of Physical Activities: Classification of Energy Costs of Human Physical Activities was used to validate MET values.²⁸

Fluid Intelligence

Fluid Intelligence measures the ability to reason quickly and abstractly. It is generally regarded as an important component of intelligence, and it assesses one's ability to solve problems in situations that are not heavily depen-

dent on previously learned knowledge. The Standard Progressive Matrices (SPM) Test designed by Raven, Raven and Court²⁹ has been used for decades in more than 2500 published research studies. The SPM test used in the current study was designed to measure educative components of general intelligence and cognitive ability. Educative ability, according to Raven et al²⁹ is the ability to forge new insights, the ability to discern meaning in confusion, the ability to perceive and the ability to identify relationships.

The SPM Fluid Intelligence Test was designed for homes, schools and workplaces as well as in laboratory settings. The SPM Fluid Intelligence Test is comprised of a given sets or series of diagrammatic puzzles exhibiting a serial change in 2 dimensions simultaneously. Each puzzle has a part missing, which the person taking the test has to finding among the options provided.²⁹ The Standard Test consists of 60 problems divided into 5 sets of 12 questions each (A, B, C, D, and E). A Total score was derived in the current study by summing all 5 sets to identify and overall score as well as specific set scores. Over 40 studies examining the reliability of the SPM Fluid Intelligence Test have been reported in the literature. The general findings include sound reliability in regards to internal consistency and retest reliability.²⁹

The SPM Fluid Intelligence Test was administered at the onset of the current study on January 22nd to the Experimental and Control Groups and was readministered during the final week in April. Regrettably, considerable amounts of children in both groups were absent from school as a result of illness, poor weather, etc during the initial administration of the SPM Fluid Intelligence Test; therefore, pre and posttest statistical examinations were not successful. However, considering all students were able to successfully complete the second administration of the SPM Fluid Intelligence Test, and there were no statistical significant differences in the demographic variables of the children in both groups, the research team was comfortable using the second administration of the SPM Fluid Intelligence Test in isolation in the current study (see *Results* for further interpretation of this limitation).

Academic Achievement

The Palmetto Achievement Challenge Tests (PACT) is a standards-based accountability measurement of student achievement in 4 core academic areas—English/language arts (ELA), mathematics, science, and social studies. The PACT items are aligned to the South Carolina curriculum standards developed for each discipline. An accountability system and a statewide test, such as the PACT, are mandated by the South Carolina Education Accountability Act of 1998 and the federal No Child Left Behind Act of 2001.³⁰ PACT was administered approximately 1 week following the last integrative lesson on the final day of the intervention. Experimental and Control Group children were simultaneously administered PACT. The South Carolina Department of Education contracts with an experienced company to print, distribute, scan, score,

and report PACT test results. Computer programming is used to score the multiple-choice questions, and trained professionals score students' constructed-response and extended writing.³⁰ These scores were not returned to this particular school district until the summer of 2008. PACT testing does not begin until 3rd grade in South Carolina, preventing the researchers from making pretest comparisons.

Teacher Training

Teachers ($n = 3$) randomly assigned to the Experimental Group received 2 training sessions before beginning the current study and received 2 additional training sessions during the study. Each training session lasted approximately 90 minutes and focused on teaching math, language arts and social studies with basic fundamental locomotor skills (ie, hopping, skipping, jumping, running, etc). Teachers assigned to the Experimental Group were provided food and refreshments during the training sessions.

Body Mass Index Measures

Body Mass Index (BMI) was calculated using Fitnessgram. This BMI protocol consisted of measuring height and weight of each child. These measures were administered by the physical education teacher at the onset of the study. These numbers were entered into the software for Fitnessgram and a BMI value for each child was calculated. This value is based on an appropriate body composition for specific weight and height and was derived during physical education. Fitnessgram uses Healthy Fitness Zones (HFZ) to evaluate fitness performance and were established by the Cooper Institute of Dallas, Texas. Students in the current study were classified as: a) in the Healthy Fitness Zone or b) not in the Healthy Fitness Zone (non-HFZ) based on Fitnessgram's specific cut point classifications for BMI.

Data Analysis

Descriptive statistics were used to examine frequencies and percentage differences for all elements of the SPM Fluid Intelligence Test, academic achievement (ie, PACT) along with BMI classification. T-tests were used to examine mean differences between PACT scores adjusted by group. In addition, Multivariate Analysis (MANOVA) statistical models were used to examine differences among results of Fluid Intelligence, academic achievement and BMI by group. The Statistical Package for the Social Sciences (SPSS) 17.0 was used to analyze the data.

Results

Description of Experimental and Control Populations

The Experimental and Control Groups had average ages of 9.42 and 9.50, respectively. Approximately 43% and

44% of the Experimental Group and Control Group children were females, respectively. Ninety-one percent of children ($n = 73$) in the Experimental Group had a BMI value, based on Fitnessgram cut points, in the HFZ compared with 75% ($n = 56$) of Control Group children; however, this difference was not significant ($P = .122$). No significant differences, when adjusted for Ethnicity, were found between groups ($P > .05$). Frequency and percentage descriptive statistics for both the Experimental and Control Groups by Ethnicity, Gender, BMI, and Age are found in Table 1.

Children in the Experimental Group averaged ($m = 1,146$) steps each integration day with a ($SD = 356$). Each integrative lesson averaged approximately ($m = 31$ minutes) with a ($SD = 4.58$). Third grade children in the Experimental Group averaged a cumulative cognitive score on the SPM Fluid Intelligence Test of 38.61 postintervention. This figure was significantly higher than children in the Control Group ($m = 36.66$; $P = .045$ [multivariate statistics will be presented later in the text]). Means and standard deviations for all 5 sections of the SPM Fluid Intelligence Test with the Total scores for both groups are found in Table 2.

The Previous Day Physical Activity Recall (PDPAR) was administered in the beginning of the study in late January and during the last week in mid-April. No significant differences were found between both groups at the initial administration (1st PDPAR Administration: Experimental Group Mean = 29; Control Group Mean = 31) as well as the second administration (2nd PDPAR Administration: Experimental Group Mean = 49; Control Group Mean = 49) of the PDPAR. Although, both groups increased their physical activity outside of school from the first administration of the PDPAR to the second, this was most likely due to seasonal changes. The initial administration was conducted in late January before Daylight Savings. The second administration of the PDPAR was completed in mid-April where there was more sunlight during the after school hours. Although, this hypothesis is based on speculation-the PDPAR measures physical activity after school and therefore it is reasonable to assume that young children would not be allowed to play outside during the dark during late January. Regardless of the increases for both groups, there were no significance differences between groups at both PDPAR administrations ($P > .05$).

Multivariate analyses (MANOVA) revealed no significant Main Effect difference preintervention for the Experimental and Control Groups by Gender, BMI, Ethnicity, and Age (Pillai's Trace = 0.035, $F = 1.020$; $df = 4, 140$, $P = .408$). Similarly, no Between-Subjects Effects were found between Experimental and Control Group children for these variables. Therefore, the researchers felt comfortable with the randomization of the classes and students in the current study. Furthermore, since no significant differences were observed between the independent variables, the researchers were confident in making comparisons between groups for the SPM Fluid Intelligence Test and achievement tests (ie, PACT) in the current study.

When all of the data were analyzed regardless of group classification, some interesting patterns emerged

Table 1 Frequency and Percentages of Demographic Variables by Group

Variable	N	Ethnicity	Gender	BMI	Age
Exp. Group	80	White = 75 (94%) Other = 5 (6%)	Female = 34 (42.5%) Male = 46 (57.5%)	HFZ = 73 (91.2%) Not HFZ = 7 (8.8%)	9 = 47 (58.8%) 10 = 32 (40%) 11 = 1 (1.2%)
Control Group	75	White = 68 (90.7%) Other = 7 (9.3%)	Female = 33 (44%) Male = 42 (56%)	HFZ = 56 (74.7%) Not HFZ = 19 (25.3%)	9 = 38 (50.7%) 10 = 36 (48%) 11 = 1 (1.3%)

Table 2 Means and Standard Deviations of Fluid Intelligence Scores by Group

Group Fluid I. Test		N	Mean	SD
Experimental	A	80	10.43	1.11
	B	80	9.94	2.14
	C	80	7.25	2.06
	D	80	8.20	1.88
	E	80	2.75	1.88
	Total	80	38.60*	6.13
Control	A	75	10.47	1.04
	B	75	9.82	1.99
	C	75	6.72	2.21
	D	75	7.57	2.76
	E	75	2.08	1.49
	Total	75	36.66	6.40

* Significance at the 0.05 level.

for the SPM Fluid Intelligence Tests. One-hundred and eleven ($n = 111$) 3rd grade children were considered a healthy weight based on Fitnessgram's cut points for the HFZ. In contrast, ($n = 26$) children were classified as having an unhealthy body composition and non-HFZ. Eighteen children in the current study did not attend school at the time of BMI classification and therefore were not included in the analysis as a result of not receiving a BMI score. Children considered a healthy weight based on Fitnessgram's classification for HFZ, earned higher scores on all components of the SPM Fluid Intelligence Test in comparison with their nonhealthy weight (non-HFZ) peers. Although only one of the components was significantly higher between the 2 BMI classification groups (SPM Section C, $F = 7.638$, $P = .007$) the total score neared significance (Pillai's Trace = 0.084, $F = 1.989$; $P = .072$). The means and standard deviations for the entire sample by BMI classification (HFZ vs. non-HFZ) of the SPM Fluid Intelligence Test are listed in Table 3.

Examination of the PACT scores by group revealed interesting results. Significant differences (t test for equality of means = 2.936, $P = .004$) between the Experimental and Control Groups in Social Studies was found. Children in the Experimental Group had a greater percentage receive a Proficient and Advanced designation than

children in the Control Group. Approximately 82% of children in the Experimental Group earned a Proficient or Advanced designation on the Social Studies PACT compared with only 60.9% of children in the Control Group.

No significant differences between the Experimental and Control Groups (t test for equality of means = 1.107, $P = .09$.) on the Math PACT were observed. Yet, children in the Experimental Group had a greater percentage of children receive a Proficient and Advanced designation than children in the Control Group. Approximately 49% of children in the Experimental Group earned a Proficient or Advanced designation on the Math PACT compared with 34.7% of children in the Control Group.

Similarly, no significant difference between the groups on English/Language Arts PACT (t test for equality of means = .711, $P = .478$) was found. Children in the Experimental Group, however, did have a greater percentage of children receive a Proficient and Advanced designation than children in the Control Group. Approximately 82% of children in the Experimental Group earned a Proficient or Advanced on the English/Language Arts PACT compared with 75.3% of children in the Control Group.

No significant difference between the groups on the Science PACT (t test for equality of means = 1.490 $P = .140$) was found as well. No child in the Experimental

Table 3 Means and Standard Deviations of Fluid Intelligence Items by BMI

	BMI Fluid I. Test	N	Mean	SD
HFZ	A	111	10.47	1.05
	B	111	9.94	2.13
	C	111	7.18*	2.13
	D	111	7.97	2.31
	E	111	2.49	1.77
	Total	111	38.02	6.42
Non-HFZ	A	26	10.38	1.23
	B	26	9.73	1.92
	C	26	5.92	1.93
	D	26	7.50	2.70
	E	26	1.96	1.39
	Total	26	35.73	5.90

* $F = 7.638$, $P = .007$.

Group scored Below Basic on the Science PACT. Children in the Experimental Group had a greater percentage of children receive a Proficient and Advanced designation than children in the Control Group. Approximately 80% of children in the Experimental Group earned a Proficient or Advanced designation on Science PACT compared with 72.2% of children in the Control Group. In addition, 41% of children in Experimental Group received a score of Advanced compared with only 25% of Control Group children. Frequencies, percentages and t test values of PACT items by Group are listed in Table 4.

Examination of the PACT scores adjusted for BMI classification (ie, HFZ vs. non-HFZ) revealed similar results to PACT scores adjusted by Group Classification (ie, Experimental vs. Control). Children classified in the non-HFZ received significantly lower scores ($F = 5.932$, $df=1, 78$, $P = .017$) on the Social Studies PACT than children classified in the HFZ BMI. Although, no significant differences were found between children on the other 3 PACT (English/Language Arts, Math and Science) tests adjusted by HFZ and non-HFZ, HFZ children received a greater percentage of Advanced and Proficient scores than their non-HFZ peers.

Conclusions

Children in the Experimental Group averaged close to 1,200 pedometer steps per day, thus averaging 3,600 steps per week during the classroom-based movement activities. This is an extremely important value since experts recommend that a 30-minute physical education class should provide children with an opportunity to accumulate 1200 to 2000 steps.³¹ The fact that the integrative movement was performed in a classroom setting with spatial constraints not observed in a gymnasium, and that the classroom teacher was not trained to teach physical

education, suggests how impressive the daily and weekly step totals were. It is readily apparent that children and adolescents based on data presented in the *Introduction* of this practicum paper are not participating in the recommended levels of physical activity contributing to a host health problems including childhood obesity. Perhaps, integrating movement regularly into the classroom can serve to reduce the risk associated with this growing epidemic.

Furthermore, previous research germane to this study has documented that studies on science³² and language arts have illustrated beneficial effects for integrating these disciplines with physical activity. An integrative curriculum provides students with a global view of learning and can teach skills necessary for the transference of knowledge gained in one area into another.³³ Both teachers and students benefit from interdisciplinary learning as it builds an understanding of other subject areas and teaching methods.^{34,46} Daryl Siedentop³⁵ a famed physical educator from The Ohio State University, posits that students learn through their involvement with the content. Integration of subject matter allows for more student involvement in the learning experiences.³⁶

As the data in the *Results* section illustrates, significant differences between Experimental and Control Group children were found on some of the SPM Fluid Intelligence Test components. These findings confirmed what was presented in the *Introduction*, and are reaffirmed by Lochbaum and colleagues³⁷ examining the relationship between exercise training history and performance on fluid intelligence. Results from their study found that aerobically trained or physically active participants performed significantly better on the fluid intelligence task than untrained or inactive participants. A more recent study published in the *American Journal of Public Health* by Singh-Manoux and colleagues³⁸ examining the impact of physical activity on cognitive function of middle-age

Table 4 Frequencies, Percentages, and *t*-test Values of PACT Scores by Group

Group	PACT LEVEL	Eng/L. Arts (%) <i>t</i> -test for equality of means = .711, <i>P</i> = .478	Math (%) <i>t</i> -test for equality of means = 1.107, <i>P</i> = .09	Soc. Stud. (%) <i>t</i> -test for equality of means = 2.936, <i>P</i> = .004	Science (%) <i>t</i> -test for equality of means = 1.490, <i>P</i> = .140
Experimental	Below Basic	1 (1.3%)	4 (5.1%)	0 (0.00%)	0 (0.00%)
	Basic	13 (16.7%)	36 (46.2%)	6 (17.6%)	9 (20.5%)
	Proficient	45 (57.7%)	24 (30.8%)	6 (17.6%)	17 (38.6%)
	Advanced	19 (24.4%)	14 (17.9%)	22 (64.7%)	18 (40.9%)
Control	Below Basic	0 (0.00%)	5 (6.9%)	10 (21.7%)	1 (2.8%)
	Basic	17 (24.6%)	42 (58.3%)	8 (17.4%)	9 (25.0%)
	Proficient	37 (53.6%)	17 (23.6%)	8 (17.4%)	17 (47.2%)
	Advanced	15 (21.7%)	8 (11.1%)	20 (43.5%)	9 (25.0%)

Note. Advanced = the student exceeded expectations for student performance based on the curriculum standards. Proficient = the student has met expectations for student performance based on the curriculum standards. Basic = the student has met minimum expectations for student performance based on the curriculum standards. Below Basic = the student has not met minimum expectations for student performance based on the curriculum Standards.³⁰

individuals revealed that low levels of physical activity was identified as a risk factor for poor performance on fluid intelligence tasks. The current investigation provides further evidence that movement can positively influence fluid intelligence of youth, and should be considered an essential element to promote cognitive development of elementary-age children in a public school setting.

Although this evidence is worth noting, what was equally compelling were the differences in SPM Fluid Intelligence Test scores for children who were distinguished, based on Fitnessgram's BMI cut points for meeting and not meeting the HFZ and non-HFZ. It was apparent that when the entire sample was examined, children who did not meet the requirements for a healthy BMI based on Fitnessgram cut points earned lower scores on many of the SPM Fluid Intelligence individual components and/or the Total Score. This finding is similar to the research by Dr. Davis from the Medical College of Georgia. Dr. Davis and colleagues³⁹ tested the effect of aerobic training on executive function in overweight children. Executive function tends to correlate with fluid intelligence and is an appropriate comparison for the current study. Fluid intelligence, similar to executive function, is related to planning and organizing information, and was related to physical activity in their study. Dr. Davis and colleagues³⁹ found that children who received the high-dose of physical activity had higher planning scores than the controls. Exercise, according to these researchers, may be a simple but important method to enhance mental function.³⁹

The executive function hypothesis originated in the field of gerontology⁴⁰⁻⁴² and is based on the idea that the largest improvements in cognition due to exercise and physical activity are on the ability to plan, initiate and carry-out activity sequences that comprise goal-directed behavior.³⁹ Regular exercise may be a simple, important method of enhancing children's cognitive and academic

development considering that, according to Welch and colleagues⁴³ executive function begins during early childhood and extends through adolescence.

Additional benefits linked to physical activity and learning was recently disseminated in a published review paper. Taras⁴⁴ revealed that physical activity improved concentration, along with reading and mathematic performance, with the strongest relationship between activity and concentration. Physical activity has also been known to stimulate the release of epinephrine and norepinephrine (adrenalin) enabling children to become alert and ready to learn.^{8,9,44}

A recent brief from Active Living Research Program Office sponsored by the Robert Wood Johnson Foundation further validates the impact of movement on academic achievement and performance. This brief provides empirically based data that concludes the following: Sacrificing physical education for classroom time does not improve academic performance. Youth who are more physically active tend to perform better academically. Kids who are physically active and fit are likely to have stronger academic performance. Activity breaks can improve cognitive performance and classroom behavior. Short activity breaks during the school day can improve students' concentration skills and classroom behavior.⁴⁵

Limitations

The primary limitation in the current study was not including pretest SPM Fluid Intelligence Data. However, as previously mentioned, Multivariate analyses (MANOVA) revealed no significant main effect difference preintervention for the Experimental and Control Groups by Gender, BMI, Ethnicity, and Age. Similarly, no Between-Subjects Effects were found between Experimental and Control Group children for these variables. Therefore, the randomization of the classes and students

in the current study was appropriate. Furthermore, since no significant differences were observed between the independent variables, the researchers were confident in making comparisons between groups for the SPM Fluid Intelligence Test and achievement tests (ie, PACT). Finally, because PACT does not begin until 3rd grade in South Carolina, this limitation prevented the research team from conducting pretest comparisons in the current study.

Implications

The primary implication arising from the current study is to offer training for elementary school teachers on how to integrate physical activity in the classroom. Integrating physical activity will not only help to teach complex information to varying children with differing learning needs, but it might also help to intervene on the risky behavior of inactivity and increased likelihood of childhood obesity. Evidence from the current study indicates that integrating movement in the classroom 3 days per week for an average of 90 minutes total per week can enhance fluid intelligence and select academic achievement scores of elementary-age children, but further studies are needed to confirm these preliminary findings.

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