PHYSICAL ACTIVITY IMPACT ON EXECUTIVE FUNCTION AND ACADEMIC ACHIEVEMENT WITH ELEMENTARY STUDENTS

Caroline Clark O'Brien

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APPROVED:

Jeanne Tunks, Major Professor
Shayla Holub, Minor Professor
James R. Morrow Jr., Committee Member
Karthigeyan Subramaniam, Committee Member
Karen Weiller, Committee Member
James Laney, Chair of the Department of Teacher Administration and Education
Jerry Thomas, Dean of the College of Education
Costas Tsatsoulis, Interim Dean of the Toulouse Graduate School

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This study tested the hypothesis that daily physical activity improves the executive function and academic achievement of 9- to 11-year-old children. The quasi-experimental, pretest–posttest design included 60 eligible fourth and fifth grade students (51.7% female, 98% Hispanic; 10.26 years of age). Twenty-five students elected to participate in school day, zero-hour (1 hour before school starts) physical activity program for 8 weeks. The 35 students who did not sign up for the program served as the control group as masked data provided by the school. Standardized measures, Adele Diamond flanker task and the Wide Range Achievement Test 4, assessed executive function and academic achievement, respectively. Repeated-measures analysis of variance was used to determine differences between groups on executive function and academic achievement. There were no observable benefits from daily physical activity on executive function and academic achievement. Convenience sampling and voluntary attendance potentially limited the effect of exercise on performance.

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To ensure children’s full development, educators must address both psychological and physiological needs. The relationship between children’s cognitive development, including executive function and academic achievement, and physical activity, is growing as an area of research (Davis et al., 2011; Diamond, 2008; Hillman, Erickson, & Kramer, 2008; Kolb & Whitshaw, 1998). According to Davis et al. (2011), due to physiological development, there is potential for exercise to have an influence on children's brain and neural growth. The ancient philosopher Plato stated that

> in order for man to succeed in life, God provided him with two means—education and physical activity. Not separately, one for the soul and the other for the body, but for the two together. With these two means, man can attain perfection. (as cited in Ratey & Hagerman, 2008, epigraph)

This study investigated the relationship between exercise and academic achievement and executive function among fourth and fifth grade children who engaged in a daily aerobic training, which consisted of 30 minutes of moderate to vigorous activity. *Executive function*, also called executive control or cognitive control, is defined as “higher level cognitive function that manages more basic cognitive functions, regulates emotion, and attention necessary for purposeful and goal-directed behaviors” (Etnier & Chang, 2009, p. 470). When students engage in rigorous physical activity, tests on executive function, which involve such mental tasks as planning, organizing, and information processing have the potential to show gains in academic achievement (Dishman et al., 2006; Hillman et al., 2009; Tomporowski, Davis, Miller, & Naglieri, 2008). Previous studies found significant associations between physical activity and academic achievement, suggesting higher intensity activity is associated with higher academic performance (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Dwyer, Sallis, Blizzard, Lazarus, & Dean, 2001; McKenzie et al., 2004).

Research on brain development and cognition informs how and why moderate to vigorous physical activity may have associations with academic achievement. Even when children participated in short bursts of physical activity, research found changes in the chemical make-up of the brain (Castelli, Hillman, Buck, & Erwin, 2007; Tomporowski et al., 2008). Harvard psychiatrist John Ratey references these chemical changes in his book *Spark* (Ratey & Hagerman, 2008), which explores the connection between the mind and exercise. He noted physical activity created neurological benefits, causing the brain to work at its peak. Ratey provides neurological background that describes how exercise optimizes brain activity to improve alertness, attention, and motivation; creates better neurological pathways by encouraging new nerve cell development and growth.

To better understand the relationships, Pate, Long, and Heath (1994) examined physical fitness and activity for youth. The report, found in *Pediatric Exercise Science*, indicates for academic achievement to be measured, definitions and clarity about physical activity habits in students must be clearly defined. The authors define *physical activity* as any bodily movement produced by skeletal muscles which results in energy expenditure; whereas exercise—often used synonymously with physical activity—is "planned, structured, and repetitive bodily movement done to improve or maintain on one or more components of physical fitness" (Pate et al, 1994, p. 435).

According to these authors, quality physical activities are those that raise and sustain a moderate to vigorous heart rate for a specified amount of time. The Centers for Disease Control and Prevention (2015) states children and adolescents need 60 minutes or more of daily aerobic physical activity in addition to muscle strengthening and bone strengthening activities. Vigorous intensity activity is recommended for at least 3 days per week. These activities can be monitored using self-reports, surveys, heart rate monitors, or accelerometers (Caspersen, Powell, & Christenson, 1985; Kirkendall, 1986; National Association for Sport and Physical Education, 2012; Sibley & Etnier, 2003; Taras, 2005; Tomporowski et al., 2008). Research examining both the quality and quantity of physical activity suggests that both have benefits for academic achievement (Dwyer et al., 2001; Hillman, Castelli, & Buck, 2005; Themanson, Pontifex, & Hillman, 2008; Wittberg, Northrup, & Cottrell, 2012).

This research provides a foundation for studying the effect of physical activity on executive function and academic achievement. This study hypothesized participants who attended daily physical activity morning exercise (AMX) would differ in executive function tasks, as measured by the change of scores from the pretest to posttest for the Flanker task and academic achievement measures (Wide Range Achievement Test 4 [WRAT4]: Mathematics, Spelling, and Reading tests), when compared to participants who did not attend AMX.

Method

Setting

All students attended a private elementary school in north central Texas that was created to engage and support predominately Hispanic children living in poverty.

Participants

Ninety-two percent of the students in the study were Hispanic, 78% of the student population was eligible for free/reduced school lunch, and 57% of the families' net income was less than $20,000 annually (Momentous Institute, 2015). All fourth and fifth grade students (*N* = 60) were eligible to participate fully in the intervention. Participants' age ranged from 9 to 11 years (*M* = 10.26 ± 0.011). Of the 25 participants in the experimental group, 98.3% were Hispanic and 11 participants were male (44%). The students in the control group consisted of 35 students whose age ranged from 9 to 11 years (*M* = 10.626 ± 0.018), 97% were Hispanic; and, 17 nonparticipants were male (49%). The treatment group attendance was 68% during the 8-week intervention. Four participants attended all the morning sessions for a 100% attendance rate.

Procedure

Participants and guardians signed an Institutional Review Board (IRB)-approved parent consent form, a student assent form, and a permission to be photographed waiver. Data from control group participants were collected by the school, masked, and provided to me. The school researchers collected masked Flanker task and WRAT4 measures on all fourth and fifth grade students. All 60 fourth and fifth grade students were invited to voluntarily attend daily, morning physical activity sessions for 8 weeks. All participants who returned parental consent forms were assigned to the experimental group. As a research-based school, the administration maintains parental permission for the students to participate in school-approved research during the course of the school year.

When interventions such as this study are introduced, additional IRB approval, parental consent, and student assent, are required by the school. Study approval was received from the University of North Texas IRB as well as approval from the school. This resulted in an experimental group of convenience, based on consent forms returned. Informed parent consent forms returned allowed students to become participants in the study and to collect heart rate and anecdotal data directly from experimental participants. Students who did not participate in AMX served as the business as usual control group. School researcher personnel collected pretest and posttest scores for Flanker and WRAT4 tests from all fourth and fifth grade students and experimental participants were coded by the school as 1 and the control participants as 0 when the results were shared with me.

Preceding the study, I conducted a 13-week pilot study at the school each morning. The pilot served to confirm lesson plans and activities were age-appropriate and maintained a moderate to vigorous pace. I used the pilot to introduce heart rate monitors, teach gross motor skills, and fine-tune lesson plans for the study. Participants provided feedback on favorite games and activities to contribute to the plans for the study. These participants for the tested study came from the pilot.

Study Design

This study's design was a quasi-experimental, pretest–posttest control group design. Students in the experimental group were a convenience sample of self-selected students that created limits on the findings of the study. The control group was the remaining students in the two grade levels who did not elect to participate. Flanker and WRAT4 data were collected twice, the first before the intervention began, during school hours the week preceding the study. The second data collection time was conducted at the end of the 8-week intervention, over the last 3 days of the study.

Intervention

AMX sessions occurred every morning, before school, for 8 weeks. All participants in the experimental group had the opportunity to wear wrist monitors and collect heart rates to ensure moderate to vigorous physical activity heart rates were achieved. Of the 25 participants enrolled, 15 participants chose to wear the heart rate monitors during activity. Fifteen participants wore the heart rate monitors for a total of 60 times. Collectively, 60 days of data were captured with an average heart rate of 142.2 beats per minute, bpm (range = 129–154 bpm), which was an average heart rate of 60 to 70% for this group. Attendance was taken and encouraged, but neither rewards nor punitive measures for non-attendance were applied.

AMX followed prescribed lesson plans that included bursts of vigorous physical activity designed to maintain an average heart rate range of 60% to 70% of maximum heart rate. Polar FT1 fitness chest straps and wrist monitors worn by 15 of the participants collected heart rate averages and time spent in physical activity for a total of 60 days. The Polar FT1 wrist monitor collected and saved the average and maximum heart rate achieved as well as length of workout. The wrist monitors collected and saved the duration and intensity of physical activity that was recorded daily. The data from the Polar FT1 were transcribed into Excel files each day.

Employing Abels and Bridges' (2010) movement education framework, participants began each class with specialized timed music interval movements, including laps, designed to raise participants' heart rates. The movement education framework provided a structured platform that supported successful, constant activity. Participants moved in prearranged movement sequences led by me along with the assistance of the PE teacher. Class continued with the lesson objective for the day and included gross motor skills such as skipping, and coordination skills such as jump roping. The objectives were embedded within games and personal best skills in order to achieve and maintain heart rates as well as make sure participants saw physical activity and movement as fun. AMX implemented the specialized timed music interval movements every 5 to 7 minutes to ensure participants' heart rates reached and maintained 60 to 70% of maximum rate. The focus during the music interval movement was locomotor skills such as: walking, skipping, hopping, side-sliding, that included larger number of steps, greater speed, and/or greatest distances between steps. The purpose of these movements was the maintenance of moderate to vigorous heart rate.

Dependent Measures

Flanker task. The Flanker task, developed by Eriksen and Eriksen (1974), tests restriction or attention to an object. Extensive use of the Flanker instrument suggests it is a valid tool for studying the phenomenon (Chajut, Schupak, & Algom, 2009; Diamond, 2008, 2013; Miller, 1991; Hillman et al., 2009; Riesel, Weinberg, Moran, & Hajcak, 2013; Zelazo et al., 2013). The National Institutes of Health (2013) "Toolbox Cognition Battery" reported test-retest reliability for the Flanker task with a value of .77.

The Flanker task instructs participants to judge target stimuli and ignore other stimuli flanking the target while measuring accuracy and response time. This study used a set of Flanker tasks developed by Diamond (2013) to measure the participants' attention and inhibitory control. The Flanker task included a script for administration of the task. This test is recommended for ages 3 to 85. As prescribed by the program, participants perform practice trials prior to testing trials to ensure full understanding of the test and ability to press appropriate keys as required by the task. There were three series of tests, or tasks, each with a rule or task. The first series, Block A, had 17 tasks to attend to the central stimulus, the arrow in the middle of the screen. The second series, Block B, had 17 tasks to attend to the arrows flanking the central object. The third series, Block C, had 45 tasks that alternate randomly between the central stimulus and the flanking stimulus. Students perform the tasks in rapid succession, pressing directional arrow buttons, based on tasks presented on the computer screen. The program collects response time and accuracy for each of the three blocks, for each student.

WRAT4. The WRAT4 assessed student academic achievement in reading, spelling, and mathematics. The WRAT4 is a paper-and-pencil assessment of academic achievement. The math portion of the WRAT4 is answered directly in the answer booklet. Administrators read the words for the spelling portion from the WRAT4 script and students write the words in the answer booklet in the predetermined blank list. For the reading portion, students are given a card with a list of words. As prescribed by the WRAT4, the tester codes the words as the students read the words out loud.

The WRAT4 is a norm-referenced achievement test that used national standardization sample of over 3,000 participants. Reliability is reported by .87 to .96 for median reliabilities for subtests (Wilkinson, 1993). The time interval for test-retest reliability was within 1 month and found reliability for Word Reading (.86), Spelling (.89) and Math Computation (.88). The internal evidence of validity between subtests found the intercorrelation range of $r = .63$ for age. External evidence of validity of correlations for individual achievement test with the Wechsler Intelligence Scale for Children-IV FSIQ include Word Reading (.74), Spelling (.57), and Math Computation (.66; Wilkinson, 1993).

Statistical Analysis

The independent variable, group participation, was used in a repeated-measures ANOVA condition by occasion that examined data from nine dependent variables across pre and posttest trials. The dependent variables included pretest and posttest for the following: Block A Flanker accuracy, Block B accuracy, Block C accuracy, Block A response time, Block B response time, Block C response time, WRAT Spelling, WRAT Reading, and WRAT Mathematics. Composite scores were collected for each block of the Flanker and for each WRAT subtest for each student to create the control and treatment group means. The repeated-measures ANOVA was used because it provides the platform to compare means between groups (participants/non-participants), while examining the pretest and posttest scores. The results of the analyses show both within and between group variance, as well as tests for significant differences between groups that potentially could be attributed to group affiliation (participant/non-participant). The analyses were set at a $p < .01$. Additional analyses included the following descriptive statistics for means and standard deviations for pretest and posttest for all dependent variables, as well as effect size for each dependent variable. The descriptive statistics provided data to conduct effect size calculations. Effect size calculations show the magnitude of the treatment effect. SPSS Version 22 was used for all analyses.

Results

Twenty-five students participated in the AMX and served as the treatment group. Thirty-five students comprised the control group. The treatment group attendance was 68% during the 8-week intervention. Of the 12 participants with greater than 90% attendance, four participants attended 100% of the sessions. Three participants attended at least 80% of the sessions. Four participants attended between 50 to 70% of the sessions. One participated in 28% of the sessions and five attended less than 25%.

Table 1 contains descriptive statistics (means and standard deviations) for the pretest and posttest Flanker (Block A, B, and C) accuracy for the control and treatment groups. Table 2 contains descriptive statistics (means and standard deviations) for the pretest and posttest Flanker (Blocks A, B, and C) response time for the control and treatment groups. Table 3 contains descriptive statistics (means and standard deviations) based on standardized scores for the pretest and posttest WRAT4 (Reading, Spelling, and Mathematics) for the control group and the treatment group.

Table 1

Mean and Standard Deviation for Flanker Scores for Accuracy

	Block A (*k* = 17)				Block B (*k* = 17)				Block C (*k* = 45)			
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control Group (*n* = 35)	90.27	0.181	94.8	0.141	86.67	0.18	0.9545	0.067	69.18	0.178	79.21	0.18
Treatment Group (*n* = 25)	92.64	0.09	96.88	0.04	88.89	0.136	94.96	0.06	70.96	0.14	80.92	0.12

Table 2

Response Time Mean and Standard Deviation for Flanker in Milliseconds

	Block A				Block B				Block C			
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control Group (*n* = 35)	818	158	656	136	881	128	657	151	801	103	799	133
Treatment Group (*n* = 25)	806	153	573	75	842	156	618	134	790	89	802	70

Table 3

Mean and Standard Deviation for WRAT4 – Reading, Spelling, Mathematics

	Reading				Spelling				Mathematics			
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control Group (n = 35)	51.67	22.46.	48.88	23.43	56.18	27.19	52.85	0.07	69.18	0.18	79.21	0.18
Treatment Group (n = 25)	51.36	22.47	54.20	21.99	60.00	23.48	53.60	21.51	61.20	19.15	66.56	21.54

Results from the repeated-measures ANOVAs for condition (AMX/no AMX) are found in Table 4. Findings show that there are no statistical significant differences for condition on any of the dependent variables: accuracy or response time for the Flanker nor on Reading, Spelling, and Mathematics for the WRAT4.

Table 4

Repeated Measures ANOVA for Condition

Condition	*F*(1, 56)	*p*
Block A - Accuracy	0.47	.49
Block B - Accuracy	0.11	.74
Block C - Accuracy	0.19	.66
Block A - Response time	2.71	.11
Block B - Response time	1.45	.23
Block C - Response time	0.03	.87
WRAT4 - Reading	0.20	.66
WRAT4 - Spelling	0.13	.72
WRAT4 - Mathematics	0.07	.79

Results from the repeated-measures ANOVA for occasion (pretest/posttest) are found in Table 5. Comparing the pretest and posttest scores for the total population there, was statistical significance for Blocks A, B, and C for accuracy and for Blocks A and B for the Flanker task ($p < .001$), as well as Spelling. There were no significant differences noted for Reading or Mathematics at the $p < .01$.

Table 5

Repeated-Measures ANOVA for Occasion

Occasion	$F(1, 56)$	p
Block A - Accuracy	11.36	.001
Block B - Accuracy	13.38	.001
Block C - Accuracy	38.10	.001
Block A - Response time	83.31	.001
Block B - Response time	135.97	.001
Block C - Response time	0.06	.802
WRAT4 - Reading	0.00	.99
WRAT4 - Spelling	8.34	.01
WRAT4 - Mathematics	4.50	.04

Results from the repeated-measures ANOVA for condition by occasion interaction are found in Table 6. There were no statistical interactions between condition by occasion identified for any of the dependent variables.

Table 6

Repeated-Measures ANOVA for Occasion by Condition

Occasion × Condition	*F*(1, 56)	*p*
Block A - Accuracy	0.01	.91
Block B - Accuracy	0.44	.51
Block C - Accuracy	0.00	.98
Block A - Response time	2.75	.10
Block B - Response time	0.00	.99
Block C - Response time	0.16	.69
WRAT- Reading	1.98	.17
WRAT- Spelling	0.83	.37
WRAT- Mathematics	0.01	.92

Effect sizes for Flanker Block A accuracy, Block B accuracy, Block C accuracy, Block A response time, Block B response time, Block C response time, WRAT Spelling, WRAT Reading, and WRAT Mathematics were calculated using the following: the overall mean of the pretest was subtracted from the posttest mean of the experimental group, and divided by the pooled standard deviation from the pretest. All effect sizes are found in Table 7. Effect sizes show a medium effect size for Flanker Block A and B for accuracy and low effect sizes for all other dependent variables. Block C accuracy and Block A and B response time show a large effect size.

Table 7

Effect Size for Flanker Accuracy, Flanker Response Time, and WRAT4 Reading, Spelling, and Mathematics

Variable	*d*
Block A - Accuracy	0.41
Block B - Accuracy	0.43
Block C - Accuracy	0.68
Block A - Response time	−1.55
Block B - Response time	−1.74
Block C - Response time	0.34
WRAT- Reading	0.12
WRAT- Spelling	−0.17
WRAT- Mathematics	0.27

Discussion

The study tested the hypotheses that fourth and fifth grade students who participated in vigorous physical activity 5 days a week, while sustaining 60 to 70% maximum heart rate, are more likely to perform better on academic measures and have quicker response times on cognitive tasks than students who did not participate in vigorous daily physical exercise. These hypotheses were based on the theoretical position posed by Ratey and Hagerman (2008) that vigorous physical activity increases academic achievement and executive function acuity. Results from this study, however, did not support the stated hypotheses. Several explanations may account for the results.

Campbell and Stanley (1963) presented a treatise on eight sources of internal and four sources of external validity. Internal validity includes factors that can affect the success or the lack of success of treatment. These factors of internal validity include history (specific events occurring between the first and second measurement), maturation, testing effects, instrumentation, selection bias, and selection maturation interaction. External validity are factors for which the experimenter could not control that are imposed onto the participants such as interactive effect of testing, selection bias of groups, and reactive effects of experimental arrangements. These sources of internal and external validity constitute the basis of the discussion that follows. Each table of data in the results section is discussed from the perspective of these precepts set forth by Campbell and Stanley.

Table 1 contains means and standard deviations for three blocks of tests, Block A, B, and C for the Flanker that collected data on the accuracy of the responses given by the students. The mean score for the accuracy for each test increased for both the control and the treatment groups. Table 2 contains means and standard deviations for the three rounds, Block A, B, and C for the Flanker that collected data on the speed of the response, as measured in milliseconds. The mean scores for the response times got faster for both the control and treatment groups for Blocks A and B. The mean scores for Block C were almost the same speed at the pretest as the posttest. Table 3 contains the means and the standard deviation for the WRAT that tested for reading, spelling and mathematics. While not significant, the treatment group mean improved for the post-test whereas the control group averaged a lower score. Both the control and the treatment groups averaged several points lower on the posttest when compared to the pretest. The control and the treatment groups both averaged an improved score for the math test. The two groups scored similarly on each pretest. The more similar the pretest the more potentially effective controlling for the main effects of history, maturation, testing and instrumentation could be considered. Factors that could have jeopardized internal validity of improved scores include maturation over the course of the 8-week study. The participants and the control group both received rigorous academics as well as consistent PE classes during the study that could possibly account for pretest to posttest gains. While instrumentation accounts for practice effect, a longer course of treatment could mitigate concerns over scoring gains.

Table 4 shows results of no statistical significance ($p < .01$) for the condition between students who participated in AMX as opposed to the control group. The maturation of all the students could have been sufficient to explain the growth in all subtests. Participants and nonparticipants received the same exposure to physical activity (i.e., PE class and recess) and academics during the school day. These factors could have been enough academic achievement and enough physical activity to suppress potential gains that participation in AMX may have explained. A selection–maturation interaction could be mistaken for effects of the treatment. Thereby, any changes or gains on posttest measures made by the treatment group could have been due to their heighten interest in participating in AMX. The desire to participate in the treatment group was not enough to create a significant difference with instrumentation used.

Table 5 shows results of statistical significance for occasion effect. All three blocks of accuracy reported statistically significant. Response time was significant for Blocks A and B, but not for Block C. In the Flanker, Block A and B ask for one rule for the Flanker, whereas Block C applies both rules randomly. Block C is a more strenuous cognitive task. Only the WRAT4 Spelling was statistically significant for occasion. Maturation of the total population could account for the overall improvement in speed and accuracy. Additionally, the effects of testing 8 weeks apart could have accounted for the significance due to developmental and academic growth. The Flanker tasks measure accuracy and speed whereas the WRAT4 measures reading, spelling, and math. The WRAT4 may not have been sensitive enough to account for any growth or change in academics over an 8-week treatment.

Table 6 reports the interaction of occasion by condition. Looking across time and occasion, there is no statistical difference of the AMX exposure on the treatment group from the control group as measured by the Flanker and the WRAT4. The effect sizes, Table 7, indicated that there are moderate effect sizes (.405, .432, and .679) for accuracy between the control and treatment groups. Response time results find a large effect size for Block A (-1.55) and Block B (-1.74). Academic achievement as measured by the WRAT4 reports effect size of .3 of a standard deviation of difference between the control and treatment groups. While there are no statistical significance on occasion by condition, the effect sizes demonstrate there are changes or differences between the treatment and control groups. Response time saw the largest effect sizes.

Overall, there was no significance found across condition as a result of AMX exposure. The Flanker and the WRAT4 may not have been sensitive enough instruments to detect change over the course of 8 weeks. To that point, a longer treatment time could be better suited for the WRAT4 and the Flanker. Additionally, a randomized sample that is larger could account for a difference between the treatment and control groups. Due to the non-experimental setting, the effects cannot be attributed to the general population.

There were no statistical significance; however, reflections from the students provide opportunities to look more deeply into impacts of daily physical activity. Most students were driven to school by working parents and have other siblings. The school setting, by design, hosts a high poverty population, a factor that could have influenced participants' ability to come to school 45 minutes early every day. Daily attendance also could have been a burden for some families; thereby parents may not have allowed their child to enroll. Participants shared reflections and conversations that parents had jobs and other siblings to take to school so regular attendance as well as punctuality were compromised for some participants. One student shared a desire to participate in AMX, but it was hard to get his parents to wake up and get him to school early due to the dark mornings and cold weather. The study ran from January to the first week of March 2014, with 3 days of cancelled or late arrivals due to inclement weather. I asked the school to consider embedding AMX into the school day, either as a first period activity or in lieu of PE class. The school was protective of its instructional time, so the study occurred during the zero-hour time and limited to voluntary participants. This resulted in a quasi-experimental design, with convenience sample group, based on volunteer participants.

Possibly, had the AMX program been embedded in the school day and a true experimental design employed, differences may have emerged due to controlling for external factors. Students who enjoy physical activity early in the morning or had parents who believed in physically active lifestyles may have had potential for selection bias into the treatment group.

The culture of the research-based school places a meaningful focus on health and the importance of intrinsic motivation. The school and teachers place value that students know what they are learning and why learning is important. Prior researchers have offered monetary or prizes for participation, however, in this study, participants and families did not receive additional benefits for participating in the program. The school leaders preferred that rewards and prizes not be included in the study, hence none were offered. This may have been a deterrent to participation as well.

Alternative Outcomes

Despite the lack of support for the hypotheses, alternative aspects pointed towards beneficial features of the AMX program. Participation averaged 68% for the 8 weeks with 10 participants attending at least 94% of the time and a range of 5 to 100% attendance. While some participants were infrequent attendees, no one withdrew or stopped attending. In written feedback from the students, participants reported feeling better about themselves and saw themselves as physically fit and active as a result of participating in AMX.

Participants reflected that they liked starting the day with music and games. Participants also noted changes within themselves—they felt as though they were calmer during classroom seatwork, paying attention in class was easier on days they attended AMX, and they had positive feelings about learning. One such reflection shared was after a few weeks of AMX, a fifth grade male was absent one morning. When I greeted the student and told him we missed him the previous day, the participant replied that he was terrible and had a terrible day prior. When asked why, the participant reflected that he had not been able to concentrate on his work, was disruptive to his class, and sent to the principal's office twice in one day. I asked what caused these problems. The participant replied that of course he had a terrible day and could not pay attention and got into trouble all because he had not started his day at AMX where he could run and play to wake up his brain. This report suggests that AMX had alternate effects that could possibly enable the student to recognize that not attending related to his performance in school.

AMX lesson plans included frequent conditioning activities, every 5 to 7 minutes that promoted students' personal best (sit-ups, push-ups, jumping jacks). AMX included games and conditioning activities that promoted personal best through self-observations of endurance and stamina. One example, between games, participants planked (holding the up position of a push-up) for at least 30 seconds during the first week of AMX. I posed the questions to the participants, "I wonder if you can go longer than 30 seconds today? And, if we practice, how long do you think you could hold a plank?" The question was posed not as a contest, but as a personal observation. The focus was on personal endurance and growth over time. The smallest participant, a fourth grader who had 100% attendance, was quietly enthusiastic and willingly participated in every activity. She never sought the limelight. However, she planked longer than other participants. The others cheered her on to reach new personal bests for her, which topped at 5 minutes. At the end of the treatment, when asked if she wanted to do AMX again, her verbal response to me was "yes, because it is fun, makes me stronger and faster." The reflection by this participant relates some positive value of the program that is worthy of continued research and understanding.

Previous research notes that heart rates are difficult to measure based on observation (Ratey & Hagerman, 2008). A fifth grade boy, the tallest in the experimental group refused to wear the heart rate monitor. He told me he would stop coming if he had to wear the chest strap. However, he was willing to stop and count his pulse at his neck. The first 5 to 7 minutes of each day found participants circling the gym using various motor skills (i.e., jog, sprint, skip, lunge) in order to raise heart rates paced to upbeat popular music. This fifth grade young man would trot, walk, saunter, and sporadically, he would sprint. To the trained and untrained eye, there was concern that he was not attaining a 60 to 70% maximum heart rate. Yet, each time I or the PE teacher called for a pulse check, he was above 60% maximum heart rate range. With further observation, he was slightly winded, as he could not always maintain a conversation while being active. He was breathing harder. While his activity level sometimes appeared low, he was engaged enough to have increased his heart rate at or above 60% maximum heart rate. This example was a good reminder that activity levels are unique and should be treated individually. By allowing the fifth graders to participate at his level of engagement, he remained a participant in the study. He achieved the moderate to vigorous heart rate. The student was allowed to control his level of participation. Future research could look at how student autonomy plays a role in understanding and making use of the benefits of daily physical activity.

During the last week of AMX informal questionnaires were administered to participants. These reflective responses provided feedback to both the school and me as we were both interested in the perceptions of the participants. To create a safe atmosphere for honest answers, students did not write their names on the questionnaire. Also I told the participants that they were the experts for AMX and their ideas and opinions would help the next session or group who would be part of AMX. Questions included the following: (a) “Why do you attend AMX?” (b) “What do you like?” (c) “Do you feel stronger?” (d) “If you taught AMX, what things would you do?” and (e) “Would you participate in AMX again?” Of the 17 participants who answered the questions, 15 answered they would participate again while two responded with a maybe. Sixteen responded that AMX was “fun” and “awesome.” At least five participants answered that they enjoyed playing and being with their friends while exercising and playing games. Quotes from the questionnaire support the notion that children could benefit from physical activity. One participant answered that AMX “wakes up my brain.” Another child noted that AMX “helps me do better in school.” Quotes included the following: “they get to have fun exercising” and “I would do it again because it is challing [sic].” Through AMX, participants shared that they saw physical activity as fun and playful. The perceived benefits included that students found they enjoyed play and play with purpose on a daily basis.

Reports from teachers and participants conveyed that there were no academic losses or negative effects. This aligns with prior research that showed no negative academic achievement findings with physical activity or fitness as the treatment (Coe et al., 2006; Stone, McKenzie, Welk, Gregory, & Booth, 1998; Zakarian, Hovell, Hofstetter, Sallis, & Keating, 1994). School administration and teachers supported the study. The school studies and incorporates the attributes of social-emotional health as well as physical health into the school. Once the study was underway, to ensure AMX was not a burden to the teachers or the school day, I attended a faculty meeting that included the principal, the fourth and fifth grade teachers, the PE teacher, and the school's research director. Teachers were able to see firsthand the influences of AMX. While statistical evidence did not support the measures used, stories and anecdotes do support student growth and enjoyment of the morning physical activity.

During the discussion, one teacher asked to see the attendance for AMX to see which of her students was enrolled. The teacher asked about a specific pupil's participation, which was sporadic. The teacher noted that on the day the student attended AMX, the teacher did not have to redirect the student's attention to stay on academic tasks; whereas, that day, the student had not attended AMX and the student was not paying attention and off task. The teacher shared that she called on the student constantly to redirect her. The teacher said she was going to encourage the student make efforts to attend regularly. During the conversation, the teacher also said she would help the student identify any connection between AMX and the academic day. This anecdotal evidence suggested that other measures of exercise program success could be valuable for future research. While this study employed measures used and recommended by prior research, it is likely these measures were not sensitive to find change in the course of 8 weeks. Teachers and students both shared observational data. Benefits were observed for self-reliance, reflection, self-perception, and productivity. Future research could look at more social-emotional measures to collect information if physical activity's influence on academics as well as behavior and self-perception.

Conclusion

Current recommendations from the Centers for Disease Control and Prevention state children should participate in 60 minutes of aerobic activity every day. Prior research informs educators that daily moderate to vigorous physical activity should be a valued part of a child's day. This study examined 20 minutes of aerobic activity with a small sample in a research-based school setting. While there were no significant statistical differences between the treatment and control groups on executive function and academic achievement, daily morning activity did not harm the academics, or the executive function, based on measures used, of the participants. Positive responses from students and educators provide evidence to begin research on other effects, perhaps behavior or social-emotional effects, as well as continue researching effects of physical activity on academic achievement.

This study demonstrates that providing children with an opportunity to play and be physically active before school allows them to see themselves as students who learn and behave better during the school day. Whether or not this specific treatment of physical activity or the opportunity to play games and socialize before school influenced how the participants felt is an opportunity for future research. This study uncovered the notion that further research in students participating in morning activity could have a relationship to how they see themselves as students and academics. Instrumentation that measures more than academics, such as self-perception or gains made could add to the field to advance the science and practice of the relationship between the soul and the body.

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