

Physical Fitness and Academic Achievement in Elementary School Children

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Background: The benefits of physical fitness are widely acknowledged and extend across many domains of wellness. The association between fitness and academic achievement, however, remains to be clarified, especially in young children. Therefore, the purpose of this study was to examine the relationship between fitness and academic achievement in elementary school children. **Methods:** Data were collected from 134 third-, fourth-, and fifth-grade children. One-mile run time, body mass index, curl-up, and sit-and-reach data were collected from physical education instructors in Middle Tennessee. The percentage of questions answered correctly for the mathematics and reading/language arts sections of the *Terra-Nova* achievement test was taken as a measure of academic achievement. **Results:** A negative association ($P < .01$) was noted between 1-mile run times and mathematics scores ($r = -.28$), whereas a positive relationship ($P < .05$) was observed between muscular fitness and mathematics scores ($r = .20$). Relative to sex differences, inverse relationships ($P < .05$) were observed between 1-mile run times and reading/language arts and mathematics scores in girls ($r = -.31$ and $-.36$, respectively), but no significant associations were evident in boys. **Conclusions:** Results from this study support a link between specific components of physical fitness and academic achievement in elementary school children.

Keywords: scholastic ability, youth, performance

A variety of health benefits are associated with physical fitness. Being physically fit reduces the risk of cardiovascular disease, colon cancer, diabetes, dying prematurely, and obesity.¹ Bone and musculoskeletal function improve, as do psychological variables, including depression, anxiety, stress, and self-confidence. In addition, improvements in work, recreation, and quality of life are associated with elevated levels of physical activity and fitness.²

Elevated levels of physical activity and fitness might also be related to better academic performance in children. Most research exploring this topic has featured subjective measurement techniques, included categorical variables (eg, achieving or not achieving the healthy fitness zones, academic grades), or has been conducted in high school or beginning elementary school students. Subjective measures of academic achievement, cardio-respiratory endurance, and muscular strength have been shown to be positively related to scholastic ability.³ Conversely, studies using self-reported physical activity have demonstrated conflicting results when examining academic performance.⁴⁻⁶ Recent data suggest that sixth-grade students who reported meeting the vigorous activity recommendations (3 or more days per week for 20 or more minutes per session) set forth in *Healthy People 2010* achieved significantly higher academic grades than students who did not meet the requirements.⁴

Limited research using objective measures of physical activity/fitness and academic achievement has indicated a positive relationship between these variables.^{7,8} Using body mass index (BMI), as defined by the Centers for Disease Control, overweight kindergarten and first-grade children demonstrated statistically lower reading and mathematics test scores compared with children at a healthy weight.⁷ A study examining fifth-, seventh-, and ninth-grade students ($N = 88,715$) also revealed a positive association ($r = .19$, $r = .22$) between overall fitness (*Fitnessgram*) and academic achievement (California Achievement Test) in reading and mathematics, respectively.⁸

Researchers have explored the impact of sex when documenting the association between physical activity/

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fitness and academic achievement in children. Whereas some research indicates the relationship is stronger for girls,^{8,9} results from other studies have reported no significant differences between boys and girls.^{3,6,10} Interestingly, no study has demonstrated the relationship between physical fitness and academic achievement to be stronger for boys.

To summarize, most studies examining the link between physical fitness/activity and academic achievement have included subjective measures, categorical variables, or have been conducted with older or very young children. Hence, additional research is needed to objectively examine the relationship of physical fitness and academic achievement in children 8 to 11 years of age (grades three to five). Therefore, the purpose of this study was to examine the relationship among the components of health-related physical fitness and academic achievement in elementary school children. In addressing this question, physical fitness and academic achievement were quantified as continuous variables and examined objectively.

Methods

Participants

Elementary school students (N = 134) in grades three to five in two local school districts volunteered to participate in this study. Students who did not complete the fitness tests and the *TerraNova* standardized achievement test were excluded from participation.

Physical Fitness Tests

Scores from the spring 2005 physical fitness assessments were collected to document physical fitness. All assessments were conducted by trained physical education instructors. Acceptable validity (.60 to .80) and reliability ($R = .62$ to $.99$) coefficients have been established for the assessments used in the study: 1-mile run, BMI, curl-up, and sit-and-reach.¹¹

The 1-mile run was used to assess aerobic fitness. The administration of this test was consistent across schools. The objective of the 1-mile run was to cover a mile in the shortest time possible. Students were encouraged to run throughout the test and to take walking breaks only as needed. Physical education instructors also reminded children to avoid starting too fast to avoid premature fatigue. Data were recorded as minutes and seconds needed to complete 1 mile. For purposes of analysis, 1-mile run data were converted to seconds.

For BMI, measures of height and weight were collected. Students were instructed to remove their shoes for the measurements. Data for weight and height were recorded to the nearest pound and quarter inch, respectively. To compute BMI (kg/m^2), data were converted into metric units of kilograms (mass) and meters (height). In some instances, height and weight were

self-reported by either the child or parent. Self-reported measures were excluded from analyses.

Muscular fitness data included tests of muscular endurance and flexibility. Scores for tests of muscular endurance and flexibility were converted to Z scores and summed to form a composite measure of muscular fitness. For abdominal endurance, the partial curl-up assessment was used. The objective of the partial curl-up test was to complete as many curl-ups as possible with a maximum set at 75. Students began the test in a supine position with knees bent and arms straight, parallel to the trunk.^{12,13} Students were instructed to keep their arms extended and slide their fingertips along the mat until reaching the specified marker using the abdominal muscles.^{12,13} Another student was responsible for counting the number of curl-ups performed. Curl-ups were completed to a cadence of 20 curl-ups per minute. Criteria for stopping the test included improper form, stopping to rest, or fatigue.^{12,13} Data were recorded as the number of successful curl-ups performed.

Hamstring flexibility was measured using the sit-and-reach test. In this test, students sat with shoes removed and legs extended with feet shoulder-width apart, against a specially constructed box. Students were instructed to reach along the measuring line as far as possible with hands on top of each other, palms down, and legs held flat.¹³ Participants completed three trials. Data from the third measurement were recorded to the nearest centimeter.

Academic Achievement Test

Mathematics and reading/language arts scores from the 2005 *TerraNova* standardized academic achievement test were collected as an index of academic achievement.¹⁴ Developed by CTB McGraw Hill, the *TerraNova* measures student progress toward proficient and advanced levels of academic performance. The reading/language arts component of the *TerraNova* assesses proficiency in content, meaning, vocabulary, writing/organization, writing/process, grammar/conventions, and techniques and skills. Subsections of number sense/theory, computation, algebraic thinking, real-world problem solving, data analysis and probability, measurement, and geometry compose the mathematics section.¹⁴ Specific data collected included the percentage of correctly answered questions for reading/language arts and mathematics. As the number of test questions varied for third-, fourth-, and fifth-grade students, computing the percentage of correct answers allowed all grades to be included in the overall sample. Instruction manuals were provided for all school personnel involved with the administration of the *TerraNova* achievement test. Criterion validity and high interrater reliability exist for the *TerraNova*.¹⁴

Procedures

To obtain access to student test records, permission was granted by local school boards and principals of participating schools. The study was approved by the University Institutional Review Board. Informed consent and child assent forms were completed by parents and children, respectively, and collected from either homeroom or physical education teachers in each participating school. Both forms were obtained from all children whose data were included in the study. After all signed forms were collected, the researcher met with the physical education teacher to obtain spring 2005 physical fitness scores.

The method of collecting academic achievement test scores was decided on by individual school principals, and, hence, varied across schools. In two schools, the researcher met with the principal to obtain scores. The principal of the third school requested a file be sent to her with all eligible students. After gathering scores for these students, the principal returned the file to the researcher. Once physical fitness scores were matched with *TerraNova* academic achievement scores, the child's name was removed from the list and replaced with a number.

Data Analyses

Descriptive statistics were calculated for all fitness and academic variables across the sample. Pearson's Product Moment Correlations were computed to examine the relationship among the health-related physical fitness components (BMI, 1-mile run, muscular fitness) and academic achievement scores (reading/language arts, mathematics). To maintain statistical power, analyses were run for the overall sample. In addition, analyses were run separately for boys and girls to allow comparison with past research that has explored differences in sex when examining the relationship of physical fitness and academic achievement. Fisher's *r*-to-*Z* transformation was used to test for statistical differences in the correlation coefficients for physical fitness and academic achievement within boys and girls. For statistical significance, an alpha level of $P < .05$ was used. All data calculations were performed using SPSS 13.0 Statistical Package for Windows (Chicago, IL).

Results

Descriptive statistics are presented in Table 1. Correlation values among variables of health-related physical fitness and academic achievement for the overall sample, as well as for boys and girls, are presented in Table 2.

Overall Sample

There was a statistically significant negative correlation ($r = -.28$) between 1-mile run times and mathematics scores, indicating that children with faster mile times

scored higher on the mathematics academic achievement test. The relationship between 1-mile run times and reading/language arts was not significant. There were no significant relationships between BMI and academic achievement in mathematics or reading/language arts. A statistically significant positive correlation ($r = .20$) was observed between muscular fitness (combination of sit-and-reach and curl-ups) and mathematics scores. No significant relationship was found between muscular fitness and reading/language arts scores.

Analyses for Girls and Boys

Whereas no significant findings were evident for boys, there was a statistically significant negative relationship ($r = -.31$ and $r = -.36$, respectively) among 1-mile run times and reading/language arts and mathematics test scores for girls. However, no significant relationships for muscular fitness and academic achievement variables were evident for boys or girls. Fisher's *r*-to-*Z* transformation revealed that the correlation results for 1-mile run times and reading/language arts scores were significantly different for boys and girls ($Z = 1.66$, $P < .05$). Thus, the relationship between 1-mile run times and reading/language arts was stronger in females. Correlation coefficients for 1-mile run times and mathematics were not statistically different for boys and girls.

Discussion

Results of this study support previous findings⁸ indicating significant relationships between components of health-related physical fitness and mathematics academic achievement scores. Whereas past research⁸ has categorized fitness as either achieving or not achieving physical fitness standards, the components of physical fitness examined in the current study were analyzed as continuous variables. Another strength of the current study was that measurements of physical fitness and academic achievement were completed within a 3-week period. Thus, fitness scores were representative of physical fitness levels at the time the *TerraNova* achievement test was administered. Extended time between fitness and academic assessments has been identified as a weakness in previous research.⁵ Furthermore, to our knowledge, this is the first study to objectively quantify the relationship between health-related physical fitness and academic achievement in children 8 to 11 years of age.

For the *TerraNova* achievement test, data were compared with the national percentage of persons who scored below proficient, proficient, or advanced in mathematics and reading/language arts. Nationally, 25% of students are categorized as advanced, 50% as proficient, and 25% as below proficient. In mathematics, scores for the current sample were higher, with 59% of students in the advanced category and 37% in the proficient category. Similar results were evident in reading/language arts. The percentages of students in the advanced and

Table 1 Descriptive Statistics of Study Variables

Variable	Overall sample		Boys		Girls	
	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
Age (y)	134	9.7 ± 0.9	73	9.7 ± 0.9	61	9.6 ± 0.8
Body mass index (kg/m ²)	54	20.96 ± 4.73	30	20.86 ± 4.34	24	21.07 ± 5.26
Mile run (s)	104	724.26 ± 188.10	58	699.22 ± 187.59	46	755.83 ± 185.96
Muscular fitness						
curl-ups (# completed)	125	39 ± 15	71	38 ± 15	54	39 ± 14
sit-and-reach (cm)	119	24.18 ± 6.64	66	23.16 ± 6.55	53	25.46 ± 6.60
Reading/Language arts (% correct)	123	76.93 ± 14.46	65	75.81 ± 14.71	58	78.18 ± 14.19
Mathematics (% correct)	123	82.90 ± 12.05	65	82.77 ± 11.47	58	83.06 ± 12.77

Table 2 Pearson's Product Moment Correlations Among Fitness and Academic Variables

Variable	Muscular fitness		BMI		Reading		Math	
	r	n	r	n	r	n	r	n
1-mile run								
total	-.15	104	.51 ^a	54	-.13	104	-.28 ^a	104
girls	-.13	46	.65 ^a	24	-.31 ^b	46	-.36 ^b	46
boys	-.17	58	-.38 ^b	30	.02	58	-.19	58
Muscular fitness								
total			-.27	54	.07	119	.20 ^b	119
girls			-.23	24	-.07	53	.22	53
boys			-.33	30	.15	65	.18	65
BMI								
total					-.07	54	-.11	54
girls					.12	24	.02	58
boys					-.02	30	-.34	30
Reading								
total							.64 ^a	123
girls							.70 ^a	58
boys							.59 ^a	65

Abbreviation: BMI, body mass index.

^a $P < .01$.

^b $P < .05$.

proficient categories were 62% and 37%, respectively. Overall, our sample was above average when compared with national percentiles for mathematics and reading/language arts.

There are potential explanations as to why the academic scores in the current sample were higher than the national average. Because only students who returned assent and parental consent forms were included in the study, it is likely that not all groups (academic scoring levels) responded equally. Children with advanced scores on the test, and their parents, might have been more inclined to participate in the study as compared with those with scores categorized as proficient or below proficient. Furthermore, students with higher levels of

fitness and/or who achieve high academic scores might be involved in after-school activities, other developmental activities, and receive more parental support. In addition, schools that were used for the analysis might not be representative of the overall school system. Data were not collected on other variables, such as socioeconomic status and ethnicity, which might also influence the differences in academic achievement scores across schools. According to public demographic information, a poverty level of 16% is reported for schools included in this study.¹⁵ Related to this point, higher socioeconomic status has been linked to higher academic achievement, as well as to better overall health.⁸

1-Mile Run

For the overall sample, a significant negative relationship was evident for 1-mile run and mathematics. Furthermore, in girls, a significant negative relationship was found for 1-mile run and both academic variables (reading/language arts and mathematics). Although modest, the negative relationship between 1-mile run times and academic variables indicates that as mile times decreased, academic achievement scores were greater. The results support the findings of Grissom,⁸ who reported higher standardized achievement test (SAT) mathematics scores in fifth-, seventh-, and ninth-graders with higher levels of overall physical fitness. Results from other research³ indicate a positive relationship between self-reported aerobic fitness and academic achievement assessed by a 5-point scale of overall scholastic ability.

BMI

There was no statistically significant relationship between BMI and either reading/language arts or mathematics scores. There are conflicting results in past research regarding the association between body composition and academic achievement, and this might be related to differences in how body composition is quantified. Dwyer and colleagues,³ for instance, found that skinfold measures of the calf and triceps were not statistically related to academic achievement scores. However, Datar, Sturm, and Magnabosco⁷ noted that overweight kindergarten children (measured by BMI) exhibited statistically lower reading and mathematics test scores as compared with children who were not overweight. It is possible that body composition might influence school performance because obesity has been linked to social problems and tiredness,¹⁶ both of which could impact learning.

Muscular Fitness

A composite measure of muscular fitness was obtained from tests of muscular endurance and flexibility. Because of the variety of tests used to assess muscular strength across schools (pull-ups, push-ups, and modified pull-ups), a muscular strength measure was not included. In the current study, a positive relationship was observed between muscular fitness and mathematics scores. Dwyer and colleagues³ concluded that although no relationship was evident between muscular endurance (sit-ups) and scholastic ability (measured by a 5-point scale), muscular strength (as measured by dynamometry) was positively related to academic achievement in 7- to 15-year-old students.

Analyses by Sex

The significant results evident in girls, but not boys, are interesting. In girls, a negative relationship was observed among 1-mile run times and academic

achievement scores in mathematics and reading/language arts. Past research examining the impact of sex has produced inconsistent findings. In agreement with the results of the current study, other researchers have reported the relationship between fitness and academic achievement to be stronger in females.^{8,9} Specifically, Grissom⁸ demonstrated that females who attained the Healthy Fitness Zone on each physical fitness assessment exhibited higher standardized achievement test scores than males in the Healthy Fitness Zone on the *Fitnessgram* test battery. Similarly, Guyot and colleagues⁹ demonstrated greater spatial ability in females with higher levels of physical fitness compared with males. In contrast, other researchers have reported no sex difference among variables of physical fitness and academic achievement.^{3,6,10,17}

Previous studies have demonstrated that girls tend to have lower self-esteem throughout childhood and adolescence than boys.^{18,19} Hence, participation in regular physical activity might play a more dominant role in positively altering self-esteem in girls. Results from a previous study²⁰ indicated a stronger relationship between verbal and spatial performance in females than in males. Although speculative, this might explain why the relationship between 1-mile run times and reading/language arts was significant for girls but was not evident for boys.

Potential Mechanisms Relating Physical Fitness and Academic Achievement

Physiological, psychological, and learned responses associated with regular physical activity might provide insight into the potential relationship between physical fitness and academic performance. Physiological mechanisms include increased cerebral blood flow, changes in hormone levels, greater arousal and stimulation, alterations in brain neurotransmitter activity, and improved nutrient intake.²¹⁻²⁶ In addition, accelerated psychomotor development; reduced feelings of tension, anxiety, and stress; and elevated self-esteem are potential psychological mechanisms that have also been reported to explain the possible association between fitness and academic achievement.^{6,16} The learned responses associated with various movement patterns of physical activity and physical fitness might also be linked to the potential relationship between fitness and academic achievement. Compared with sedentary activities such as watching television, engaging in regular physical activity is likely more mentally challenging.²³ Findings from past research also suggest that the experiences associated with learning movement and physical activity might accelerate cognitive development.²⁴ Skills, such as spatial organization, acquired through physical activity, might carry over into spatial conformations of relationships that comprise words and mathematical operations.²³

Conclusion

In conclusion, results from our study support a link between specific components of fitness and selected indices of academic achievement. Specifically, in elementary school children, a modest association was observed among the physical fitness variables of muscular fitness and 1-mile run times and mathematics achievement scores. Moreover, when separate analyses were conducted to examine differences between boys and girls, the relationship between academic achievement and 1-mile run time was evident in girls but not in boys.

Future research in this area should focus on understanding the mechanisms supporting this association. In addition, studies quantifying changes in academic performance resulting from the implementation of physical fitness/activity programs during various stages of childhood and adolescence should be conducted. Although small, the variation in selected academic subjects accounted for by physical fitness (4% to 7% for muscular fitness for the full sample and 1-mile run times for girls, respectively) suggests that the promotion of an active lifestyle in elementary school children might potentially enhance academic learning and achievement.

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