

Physical and Psychological Effects of Aerobic Exercise in Boys with Learning Disabilities

JAMES R. MACMAHON, M.D.
RUTH T. GROSS, M.D.

Division of General Pediatrics, Department of Pediatrics, Stanford University School of Medicine, Stanford, California

ABSTRACT. Aerobic exercise has been associated with improvements in psychological status and physical fitness in adults, but its effects on children are less clear. The purpose of this study was to evaluate the effects of an aerobic exercise program on the self-concept, academic achievement, motor proficiency, and cardiovascular fitness of boys with learning disabilities. Fifty-four boys were randomly assigned to one of two exercise programs lasting 20 weeks. One program emphasized aerobic exercise and the other consisted of similar but less vigorous activities. The self-concept, academic achievement, motor proficiency, and physical fitness of each subject was assessed before and after the exercise programs. The results from group comparisons demonstrated an association between the aerobic exercise program and improvement of self-concept and physical fitness. No effect on academic achievement or motor proficiency could be attributed to the aerobic exercise program. *J Dev Behav Pediatr* 8:274-277, 1987. Index terms: aerobic exercise, learning disabilities, sports, self-concept.

Learning disabilities have a profound effect on the self-esteem, quality of life, and social adjustment of school-age children.¹⁻⁷ Students with learning disabilities participate less often in recreational physical activity⁸ and perform less well on tests of physical fitness,⁹ when compared to normal children. The question thus arose as to whether a relationship can be demonstrated between exercise and psychological development among the learning disabled. Studies in adults, for example, have associated aerobic exercise with improvements in cognitive function,¹⁰⁻¹⁵ mood,¹⁶⁻¹⁹ social success and general psychological well being.¹⁶⁻²⁰ The effects of exercise on children are less clear, as previous studies showing psychological or academic improvements in those participating in organized exercise programs have failed to document either the intensity of the exercise or the impact on physical fitness.²¹⁻²³ Furthermore, methodologic deficiencies, such as the use of inappropriate comparison groups, have often compromised these studies.²⁴ Although fitness training offers psychological benefits to children with physically handicapping conditions, such as cardiac disease,²⁵ a direct effect of exercise on the psychological status of learning-disabled children has not, to our knowledge, been evaluated in a randomized controlled study. If aerobic exercise provides physical or psychological benefits to children with learning disabilities, then it could play an important role in remediation programs for these children.

The present study investigated the physical and psychological effects of aerobic exercise on children with

learning disabilities, using a randomized prospective comparison of two exercise programs in a sample of boys ages 7 to 13 years. The study was designed to test the hypothesis that boys with learning disabilities who participate in a structured aerobic exercise program will show more improvement in measures of physical fitness, self-concept, academic achievement, and motor proficiency than those participating in a comparable, but nonaerobic, exercise program.

METHODS AND MATERIALS

The study population was drawn from a private school which enrolls only children who are average or above average intelligence as measured by the Wechsler Intelligence Scale for Children-Revised (WISC-R)²⁶ and who have been diagnosed as learning disabled through a battery of educational tests, including the Wide Range Achievement Test (WRAT).²⁷ Each student's WRAT scores were more than 1.5 standard deviations below his overall WISC-R score. In addition, the students showed a pattern of errors on the Slingerland Screening Tests for Identifying Children with Specific Language Disability²⁸ consistent with a diagnosis of a learning disability. This school draws from a homogeneous middle-class population. Informed consent was obtained from the children and their parents. Sixty boys were invited to participate in this study; four parents declined initial consent, and two students withdrew. No identifiable characteristics differentiated these six from the study participants. The 54 boys who were included in the study ranged in age from 7.1 to 12.75 years (mean age 9.7 years). The study protocol was approved by the medical committee for the use of human subjects in research at Stanford University.

Address for reprints: James R. MacMahon, M.D., Division of General Pediatrics, Department of Pediatrics, Stanford University School of Medicine, Stanford, CA 94305.

Design

The subjects of this study were randomly assigned to one of two groups participating in separate sports programs. The aerobic group's exercise, which consisted of distance running, aerobic dance, and variants of soccer, raised subjects' heart rates above 160 beats/min for 25 minutes, 5 days/week for 20 weeks. This level of exertion has been associated with improved fitness in adults. The comparison group participated for the same period of time in a structured program of games and less vigorous physical activity intended to maintain heart rates below 150 beats/min while avoiding any sustained elevation of heart rate. Activities for this group included slow moving relay races through maze patterns, dodge ball, and volley ball. To assess the intensity of the exercise experienced by both groups, randomly selected students were monitored during the exercise programs with a portable heart rate monitor (Exersentry). This compact and lightweight monitor rests unobtrusively in a chest harness and provides a digital display of heart rate. The only difference between the two programs was the intensity of the exercise. The two groups were coached by the same teachers, who were not aware of the outcome variables of this study.

Self-concept, physical fitness, academic achievement, motor proficiency, and anthropometry were measured for each subject before and after participation in one of the exercise programs. These measurements were carried out by the school staff and by the participants in this project, who were unfamiliar with the subjects' group assignment.

Instruments

The choice of specific instruments used to measure outcome variables of this study was based on their widespread acceptance and usage, their standardization, and their practicality.

Self-concept for each child was evaluated by the Piers-Harris Children's Self-Concept Scale.²⁹ The 80 items of this questionnaire require a simple yes/no answer. The questions were read aloud to the students to compensate for any reading difficulties. The Piers-Harris Children's Self-Concept Scale was used as the measure of self-concept because it has been used in other populations of children with learning disabilities,³⁰ and because its simple format lends itself to use among children with organizational or learning handicaps.

TABLE 1. Piers-Harris Children's Self-Concept Scale—Percentile Scores (group mean \pm SD)

	Before Intervention	After Intervention
Aerobic group	73.6 \pm 29	80.3 \pm 23 ^a
Comparison group	67.3 \pm 26	67.8 \pm 28
Level of significance of difference between groups	NS	$p < 0.05$

^aIncrease in score from previous measure significant at $p < 0.05$ level.

Cardiovascular physical fitness was assessed by submaximal exercise testing using a cycle ergometer (Monark) with a weight-calibrated workload. The workload that raised a subject's heart rate to 170 beats/min, known as the physical working capacity (PWC-170) of that individual, was used as a measure of physical fitness. This value has been shown to correlate well with measures of oxygen consumption.³¹ Following the protocol of Sjostrand³² and Wahlund,³³ the PWC-170 was calculated for each subject by extrapolation, using the heart rate plateaus recorded when the subject pedaled at each of three standard workloads. The PWC-170 values were corrected for body size using body surface area.³⁴

The Wide Range Achievement Test, which yields age-standardized percentile scores for word recognition, arithmetic computation, and spelling,²⁷ was used to measure academic achievement.

The short form of the Bruininks-Oseretsky Test of Motor Proficiency was used in assessing coordination and motor proficiency.³⁵ This instrument provides age-standardized percentile scores of overall motor proficiency based on tasks involving fine motor, gross motor, balance, reflex, and rhythm skills.

Also recorded for each subject were the age, height, weight (by balance scale), and triceps skinfold thickness (by Lange caliper).

Statistical Methods

The data were analyzed by Student's *t*-test to compare group means. Since the literature suggested that training would, if anything, improve psychological functioning and physical fitness, one-tailed tests of significance were employed with both the psychological and fitness measures.

RESULTS

Prior to the initiation of the exercise programs, there was no significant difference between the two groups in self-concept, fitness, academic achievement, motor proficiency, or anthropometry. After the exercise programs were completed, significant differences were found in the measures of self-concept and physical fitness. The aerobic group performed better than the comparison group in both of these areas (Tables 1 and 2). The aerobic group showed an improvement in the mean percentile score on the self-

TABLE 2. Physical Fitness Score^a (group mean \pm SD)

	Before Intervention	After Intervention
Aerobic group (<i>n</i> = 27)	394.2 \pm 81	416.6 \pm 84
Comparison group (<i>n</i> = 27)	360.9 \pm 62	373.4 \pm 63
Level of significance of difference between groups	NS	$p < 0.05$

^aScores represent physical working capacity (kg \cdot m/min) divided by body surface area (M²).

concept scale from 73 (before) to 80 (after the intervention). The comparison group showed no change. After intervention, cardiovascular fitness, as measured by the physical working capacity (PWC-170), adjusted for body size, was improved in both groups. The post-intervention mean score of the aerobic group was significantly better than that of the comparison group (Table 2). No significant differences between the two groups were measured in either academic achievement or motor proficiency.

DISCUSSION

This is, to our knowledge, the first study of the psychological and physical benefits of aerobic exercise in learning-disabled children in which there was a prospective randomized comparison of two types of programs. Randomization is an important feature of the study design, as the extracurricular activities of these subjects could not be controlled or monitored. The documentation of exercise intensity and the similarity in the structure of the exercise programs were essential components of the study design. The measures of physical fitness (PWC-170) serve two functions: (1) to ensure that the two exercise programs differed sufficiently in intensity to have measurably different physiological effects, and (2) to support previous studies showing that aerobic exercise can measurably affect cardiovascular physical fitness in this age group.³⁶⁻³⁹

The data from this study indicating that the boys assigned to an aerobic exercise program experienced an improvement in their measure of self-concept is especially pertinent, as the literature suggests that children with learning disabilities usually have poor self-concepts.⁴⁰⁻⁴² Whether the findings of this study can be generalized to other populations, or to other groups with learning disabilities, remains to be tested.

Why self-concept improves with such a program, i.e., the possible mechanism by which aerobic exercise influences psychological variables like self-concept, is unknown. Despite much interest in this subject, the mechanisms remain theoretical,^{24,42-48} and include such varied theories as increases in endogenous opioids, decreases in stress hormones, the effects of meditation and relaxation, and the sense of mastery of body control. Whether the psychological benefit represents a direct effect of physical

changes, or is independent of fitness measures, is not clear from previous studies. An initial exploration of this issue was conducted with the data from this study, using a correlation matrix and multiple linear regression. Although the results suggested that the improvement in self-concept was more closely associated with participation in the aerobic exercise program than with actual improvement in cardiovascular fitness, many more subjects would be required for a study to have sufficient power to explain the complex mechanisms involved.

Without knowing the mechanisms by which aerobic exercise and psychological status are related, it is difficult to estimate the duration of an exercise program needed to maximize psychological benefits. Improvement in physical fitness may be measured within several weeks. However, it has been suggested that short-term interventions are unlikely to change measures of basic personality traits.^{14,19} Since self-concept is usually relatively stable over time²⁹ and academic achievement depends on a lengthy process of learning, it is possible that a similar study conducted over a longer period of time would produce different findings from those reported here.

CONCLUSIONS

The results of this study lead to several conclusions. First, participation in an aerobic exercise program is associated with improved self-concept in 7- to 12-year-old boys with learning disabilities. Second, neither aerobic exercise nor improved physical fitness was demonstrated to affect academic achievement or motor proficiency. Third, an aerobic exercise program can be associated with measurable improvements in the physical fitness of learning-disabled boys, ages 7 to 12 years.

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