April 1996: (II)S32–S36

Habitual Physical Activity and Academic Performance

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Introduction

Kirkendall (1985) reviewed the effects of physical activity on intellectual development and academic performance. The better private schools have long recognized the value of developing a healthy mind in a healthy body, but state and municipal school boards in North America have often approached physical education from a negative standpoint. Pointing to growing pressures on overall curricular time, they have argued that hours "wasted" on required physical activity programs would have an adverse impact upon overall academic performance (Hansen 1990, Hanson and McKenzie 1989, Mullane 1989).

There are thus three important issues to be discussed in this paper:

1. Does involvement in a regular physical activity program improve or worsen academic performance?
2. Are any changes in academic performance associated with changes of cognitive or psychomotor function, as assessed by formal tests?
3. What alternative explanations can be offered for any observed changes?

Methodology of the Trois Rivières Experiment

In discussing these three questions, particular reference will be made to the Trois Rivières experiment, undertaken jointly with Dr. Hugues Lavallée in the Province of Québec (Shephard et al. 1984, Shephard and Lavallée 1994, Volle et al. 1984). The Trois Rivières experiment involved 546 primary school students from an urban and a rural school in the St. Maurice region of Québec. The curriculum of the experimental students was modified in grades 1 through 6 to incorporate 1 hour per day of additional physical activity, taught by a specialist physical educator. Control students were drawn from immediately preceding and immediately succeeding classes at the same schools. They were thus exposed to an identical domestic and overall academic environment but spent some 13–14% more school time on academic instruction.

All students attended the Trois Rivières laboratory annually, within 2 weeks of their respective birthdays. At these visits, general health, psychomotor and cognitive function, and a wide variety of other observations were made. Academic performance was reported by the homeroom teacher at the end of each school year, and a provincewide examination was completed toward the end of grade 6.

Academic Performance

Trois Rivières Experience

A total of 2282 local academic report cards were evaluated, 884 from the urban school and 1398 from the rural school. For the purpose of statistical analysis, alphanumeric ratings of A through F were converted to a corresponding linear digital score (1=high, 6=low academic performance). A student's overall academic performance for any given year was computed as the unweighted average of marks for the parental language of French (four assessments covering the ability to listen, talk, read, and write), mathematics, English (upper grades only), natural science, and overall conduct (the mean of five annual assessments).

Students in the control classes initially had better grades than the experimental students (**Figure 1**, $p<.001$), but in grades 2 through 6, the experimental students outperformed the controls, significantly so in grades 2, 3, 5, and 6. The girls outperformed the boys in all grades, and MANOVA showed a highly significant sex/program interaction, with the girls gaining a larger academic advantage than the boys from participation in the experimental program.

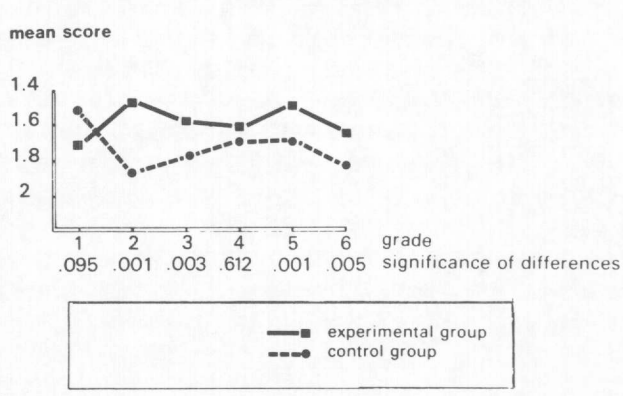

Figure 1. Comparison of overall academic performance (1=high, 6=low) between experimental and control students.

The number of assessments per subject area was limited, and the impact upon individual subject areas was thus analyzed in terms of categoric comparisons between entire classes of experimental and control students. The marks for French language instruction favored experimental classes in 13 comparisons and control classes in 6 instances, with no differences in 26 other comparisons. In mathematics, experimental classes obtained higher marks in 4 comparisons, equal marks in 8 comparisons, and no poorer marks. In English language, experimental classes had higher marks in 2 comparisons, similar results for 1 comparison, and poorer marks in 1 comparison. Natural science instruction showed an advantage to experimental classes in 4 comparisons, equal performance in 3 comparisons, and poorer performance in 1 comparison. Deportment was unchanged by the experimental intervention, except in grade 6, where 1 of the 2 comparisons favored the experimental class. A Chi2 analysis based on all comparisons strongly favored the experimental students ($p<.001$).

The provincewide examination was of the multiple choice variety. Many educationalists would argue that such examinations are susceptible to "cramming," thus providing a less valid measure of overall academic attainment than teacher ratings. Moreover, opportunities for such cramming inevitably increase with the number of hours spent in the classroom. Perhaps for this reason, the provincial scores showed no intergroup difference for French language, a significant advantage to the experimental group in mathematics (scores of 23.8±7.9 versus 18.5±6.1, $p<.001$), but lower ratings for English (22.2±6.1 versus 27.4±6.8, $p<.001$) and "overall intelligence" (40.8±10.3 versus 62.6±14.0, $p<.001$).

Other Studies

A study of students conducted in Vanves, a suburb of Paris (Fourestier 1966, Hervet 1952, Ministère de l'education nationale, de la jeunesse et des sports 1957), received wide publicity, although it has never been published in the English language literature. A new program assigned half of each school day to physical activities (gymnastics, swimming, physical training, sport, and athletics), with the students involved receiving 26% less normal teaching than a control group. Academic progress was said to be unchanged despite the major curtailment of classroom instruction.

Young (1979) reported gains in various measures of intelligence and brain function after adults had participated in a 10-week aerobic program, although part of the observed gains could be a learning effect since no controls were included.

Other authors have compared the academic performance of students enrolled in special sport schools (Pietrini 1981) or school athletes (Davis and Berger 1973, Davis and Cooper 1934, DiGiovanna 1937, Hackensmith and Miller 1938, Lueptow and Kayser 1973) with their nonathletic peers. Although the athletes fared well in such comparisons, few conclusions can be drawn from such observations because athletic involvement was self-selected, and often students also received additional academic coaching or were graded more leniently than their nonathletic peers.

A few reports have correlated fitness (Hart and Shay 1964, Klausmeier et al. 1960) or physical skill (Johnson 1942) levels with academic performance. Again, it is difficult to dissociate any reported benefit from the self-selection of students who are high achievers both in the classroom and on the sports field.

Conclusions

We may conclude that classroom assessments suggest that academic performance per unit of class time is enhanced rather than worsened if curricular time is assigned to required programs of habitual physical activity. "Objective" provincewide tests support this viewpoint for mathematics but, in the Trois Rivières study, do not confirm benefit in language or in "overall intelligence."

Cognitive and Psychomotor Performance

Theoretical Considerations

Regular physical activity might influence cognitive development by increasing cerebral blood flow, altering arousal and associated neurohormonal balance, changing nutritional status, or promoting the growth of interneuronal connections.

Young children typically engage in short but sharp bursts of physical activity, and any impact of exercise upon carotid perfusion seems likely to be small and short-lived. The average level of arousal is likely to be greater in an active than in a sedentary student, and this would facilitate a favorable interaction between the learning environment and cognitive development. Mental performance is also influenced by certain exercise-modulated hormones; serotonin levels tend to be negatively correlated with vocabulary scores (Cook et al. 1988, Kuperman et al. 1987), and IQ is positively related to testosterone levels in men, although it is negatively related to testosterone concentrations in women (Tan 1990). The active child has a greater overall intake of nutrients, and this could theoretically optimize the intake of essential fatty acids, vitamins, and trace elements (Benton 1992), although there is little evidence that nutritional deficiencies limit intelligence in developed societies (Nelson 1992, Nelson et al. 1990). Finally, various authors (Chissom 1971, de Mondenard 1989, Drowatsky and Geiger 1993, Eckert 1975, Plack 1968) have supported the concept of an association between psychomotor training and cognitive development (Piaget 1956, 1967). According to Piaget's hypothesis, the skills of spatial organization required for active play carry over into an understanding of the spatial conformations and relationships that comprise words and mathematical relationships.

Trois Rivières Experiment

Students performed Goodenough and WISC tests annually. The Goodenough test (Aikman et al. 1992, Goodenough and Harris 1950) requires students to "draw a man", and the student's performance is judged on 73 items, such as the accurate representation of body parts, clothing detail, perspective, and proportion. Scores, which are moderately correlated with both full-scale IQs and academic achievement (Aikman et al. 1992), showed no differences between experimental and control students.

On the WISC test, students assigned to the experimental program tended to an advantage over controls ($p<.10$) in three items on the verbal scale (comprehension, arithmetic, and similarities, **Table 1**). Differences amounted to about 4% for verbal skills and 3% for nonverbal items, although the only statistically significant advantage was for picture completion (1.4 units difference in score, $p<.05$).

Table 1. WISC scores for experimental and control students (probabilities established by 3-way MANOVA also testing for effects of sex, environment [urban versus rural], and interactions between these factors)

Item	Experimental	Control
Global score	109.0	104.7
Verbal scale		
Information	9.08	8.32
Comprehension	9.50	8.51*
Arithmetic	11.02	10.35*
Similarities	12.36	11.22*
Vocabulary	12.00	12.37
Subtotal	105.4	101.0*
Nonverbal scale		
Picture completion	12.00	10.59**
Picture arrangement	10.40	9.57
Block design	11.86	12.41
Assembly	11.36	11.29
Coding	12,32	11.84
Subtotal	111.2	108.0

*$p<.10$, **$p<.05$

In the early stages of the program, experimental students outperformed control students on a number of tests of psychomotor function such as the perception of body size, perception of the vertical, and finger recognition (Volle et al. 1984). However, this seemed an advancement of normal development rather than a permanent gain of psychomotor ability, since control students made good their disadvantage of psychomotor function as they progressed through the school.

Scores on the finger recognition test of Nadine Galifret-Granjon were significantly correlated with the scores obtained on a number of the WISC scales (**Table 2**).

Table 2. Pearson coefficients of correlation between finger recognition test scores and measures of intelligence on the WISC scales

Variable	Correlation coefficient
Global IQ	.307*
Nonverbal IQ	.334*
Story in picture	.347*
Block designs	.250**
Assembly	.275**

Source: Beaucage (1977).
*$p<.001$, **$p<.01$

Conclusion

There is limited empirical evidence suggesting that gains in academic performance reported by classroom teachers are associated with small gains in scores on certain WISC scales. However, any effect is small (3–4%) and could reflect the extraneous influences discussed below rather than an intrinsic effect of regular physical activity upon cognitive function. Any impact of psychomotor training upon intellectual function of the type proposed by Piaget (1956, 1967) is apparently short-lived, since experimental students showed an advantage of psychomotor performance only in the lower school grades. Such a mechanism could not explain the continuing academic advantage of experimental students seen in the higher grades.

Some Alternative Explanations

Teacher-related Effects

In the Trois Rivières experiment, the experimental students showed their main advantage of academic performance in the grades assigned by the homeroom teachers. Such assessments have many advantages but are vulnerable to the attitudes of the teachers concerned. Some 80% of teachers favored the experimental program, and the remaining 20% had a neutral attitude. The reported student achievements may thus have been enhanced by some type of a "halo" effect, with teachers assigning higher grades to students who were enrolled in what they regarded as a better program. We have argued (Shephard and Lavallée 1994) that the likelihood of such an artifact was minimized because in any given year, the homeroom teachers assigned marks only for experimental or control students. Furthermore, the teachers expressed a belief that the program had enhanced deportment (although this was not reflected in their mark assignments), and they were unaware that the experimental intervention had a larger positive impact upon the academic performance of the girls than on that of the boys.

It is more difficult to determine whether the quality of instruction by the homeroom teacher was better in the years when students were enrolled in the experimental program. Certainly, the academic faculty concerned had a daily 1-hour break from teaching during these years, and

this break may have allowed them to return to the classroom fresher and better prepared to teach.

Student-related Effects

Involvement in the physical activity program may have induced an immediate arousal and relief from boredom, with the result that the students paid more attention to instruction during the latter part of the school day. Sport may also have provided more mental challenge than the common alternative of watching television (Williams and Haertel 1982), although at least equal mental benefit might well have been gained from some other challenge, such as playing chess or a musical instrument.

In a more long term sense, the increase in motor skills resulting from the increased physical activity instruction may have enhanced self-esteem (Schendel 1965, Schurr and Brookover 1970), leading to better classroom behavior and a greater desire to learn (Bluechardt et al. 1994, Cantell et al. 1994). The absence of change in deportment and the fact that all students in any given class were exposed to the same program argue strongly against such an explanation.

The additional exercise may also have induced changes in body build, enhancing self-esteem (Teasdale et al. 1992). Again, the design of the Trois Rivières experiment limited the operation of such an effect, since all students in any given class were exposed to the same program.

Policy Implications

Daily programs of physical education should not be introduced with the expectation that they will lead to major gains in academic performance. However, the available data suggest that the rate of academic learning per unit of class time is enhanced in physically active students and that lack of curricular time is not a valid reason for avoiding daily physical education. In view of the importance of establishing positive health habits at an early stage in development, school boards should be encouraged to introduce daily quality programs of physical education beginning at the primary school level.

Acknowledgment

The research support of Canadian Tire Acceptance Limited is gratefully acknowledged.

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